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TIME DIFFERENCE SURVEY SYSTEM (TDSS).(U)
APR 81   A J SEDLOCK, T J MILNE, J P LEWICKI

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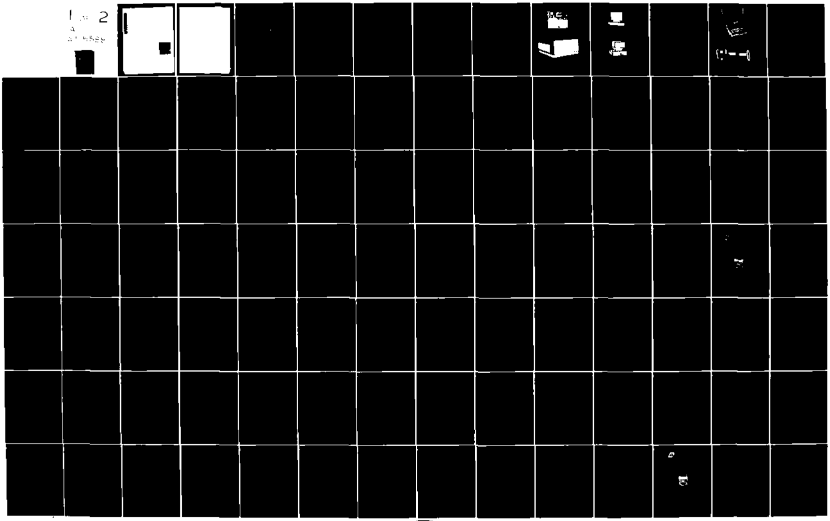

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16. Abstract

A primary concern of the U.S. Coast Guard is the development of a system using Loran-C to enable vessels to accomplish precision navigation in harbors, harbor entrances (HHE), and restricted waterways. The need for this system is especially great during periods of low visibility or when more conventional aids to navigation are not available.

A visual survey method is the basic approach for a Loran-C Time Difference (TD) grid survey in restricted waterways. The shipboard visual navigation approach relates the surveyed Time Differences (TD's) to the world of the mariners.

The result is a set of waypoints (i.e., intersection of two visual ranges) measured in TD's which relate to the actual location of channel edges, shoals, buoys, and other aids to navigation.

This report describes the Time Difference Survey System (TDSS) which was developed at the U.S. Coast Guard R&D Center to accurately and efficiently measure, record, and process the TD information.

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METRIC CONVERSION FACTORS

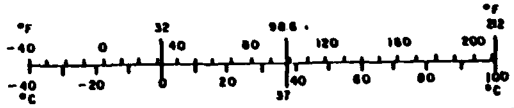
Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in ≡ 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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1.0 GENERAL INFORMATION

1.1 Introduction

The TDSS is a data acquisition system designed to collect Loran-C time difference and vessel position data for Loran-C harbor survey applications. The system provides a real-time graphic display of the data collected and calculates cumulative statistics including linear regression parameters.

The TDSS consists of a Hewlett-Packard HP9845B desktop calculator, an AUSTRON 5000 Loran-C monitor receiver, and a Motorola Mini-Ranger positioning system. The use of Mini-Ranger is optional and depends on the survey applications. The HP9845 is interfaced to the AUSTRON 5000 via an RS232 link operated at 9600 baud. The HP9845 and Mini-Ranger are connected via 16-bit and BCD interfaces. The 16-bit interface is used for control functions and the BCD interface for data transfer. A real-time clock option on the HP9845 is used to generate sample requests from the AUSTRON 5000 and Mini-Ranger.

1.2 General Description

1.2.1 AUSTRON 5000 Loran-C Monitor System

The AUSTRON Model 5000 Loran-C Monitor System is a computer-controlled Loran-C system specifically designed to do real-time data gathering for up to four Loran-C chains (see figure 1-1). The receiver is capable of tracking more than one chain and can be used on a time-shared basis by more than one user. The system consists of a receiver section which filters and amplifies the Loran-C signal and then digitizes samples upon command from the computer section. The receiver is controlled by a PDP-8 minicomputer (see figure 1-2). Processed data in the form of time differences, envelope data, receiver gain, and noise data is transmitted from the computer. The receiver initialization, control, and system checks for proper tracking is done through various commands. (See appendix A.) The status of the chain is carefully monitored and should an abnormal condition occur, the receiver will recognize this condition and respond with a corresponding error message. For a complete listing of messages, see the AUSTRON 5000 Fault Command Dictionary in appendix B.

1.2.2 Hewlett-Packard 9845B Computer

The H/P 9845B is a high-speed versatile computer utilizing the Enhanced BASIC[1] language. (See figure 1-3.) It is designed for both the programmer and the system operator since it can be used interactively for writing and debugging programs and entering data.

The H/P 9845B system features the following:

Keyboard - Full 128-character ASCII set, color-coded and configured like an office typewriter.

[1]Beginner's All-Purpose Symbolic Instruction Code

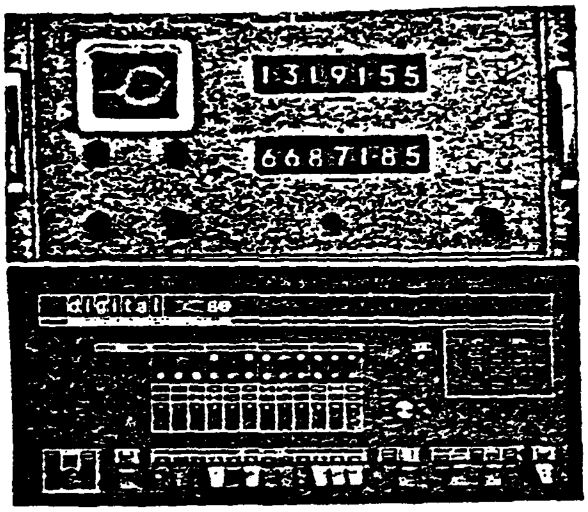


FIGURE 1-1 AUSTRON 5000 NAVIGATION SYSTEM

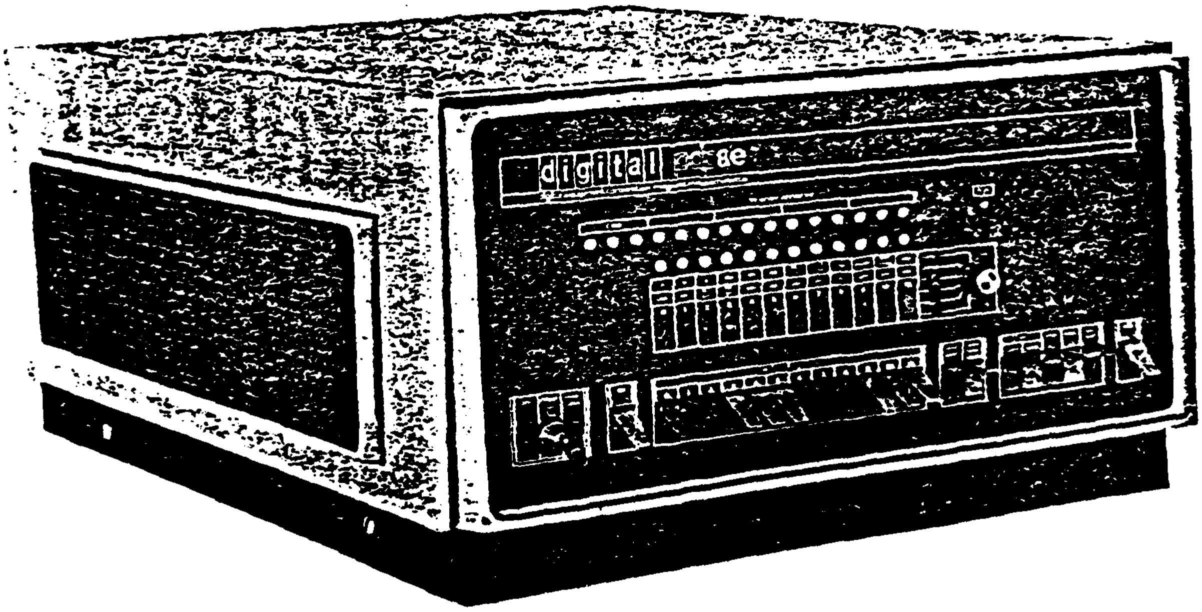
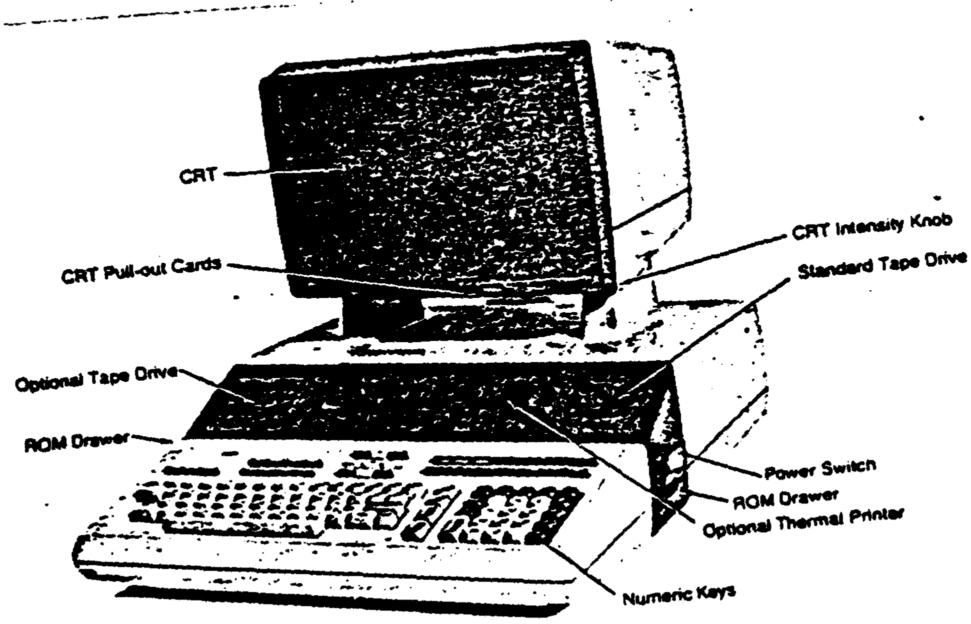


FIGURE 1-2 PDP-8/E PROCESSOR



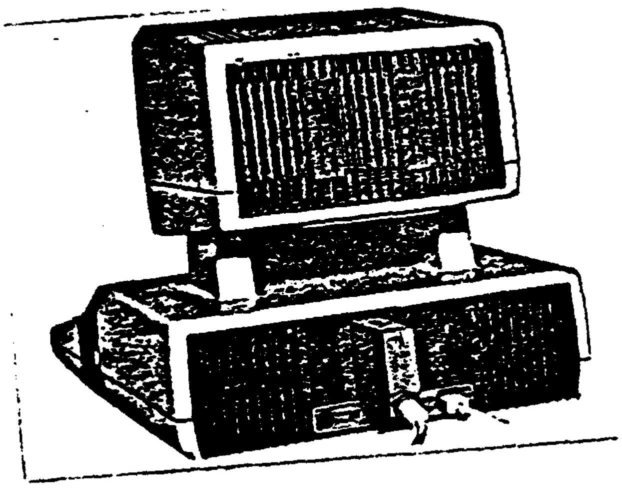


FIGURE 1-3 9845B COMPUTER

CRT - 80-character by 24-functional-line Cathode Ray Tube (CRT) display.

ROMs - There are several plug-in Options Read Only Memories (ROMs) which provide additional language capabilities to perform specific tasks, such as using mass storage devices, graphics, I/O, and advanced programming.

Internal Printer - The optional internal thermal printer is an 80-character line printer used for hard-copy output.

Tape Drive - The two tape drives built into the System 45B main frame (one is standard, the second is optional) provide an easy-to-use storage capability of 217K bytes (or about 847 physical records) per tape cartridge.

Language - The BASIC language as implemented on the System 45B Computer is an enhanced form of HP Compatible BASIC.

1.2.3 Mini-Ranger III System

The Mini-Ranger III System (MRS III) shown in figure 1-4 is used to accurately determine the position of a mobile unit such as a vessel, aircraft, or land vehicle. This position is determined with respect to Reference Stations located at known, fixed points.

The MRS III, operating on the basic principle of pulse radar, uses a transmitter (located on the mobile unit) to interrogate the reference stations. The elapsed time between the transmitted interrogation produced by the MRS III transmitter and the reply received from each reference station is used as the basis for determining the range to each reference station. This range information, displayed by the MRS III together with the known location of each reference station, can be trilaterated to provide a position fix of the mobile unit. The standard MRS III operates at line-of-sight ranges up to (approximately 37 kilometers) 20 nautical miles and, with appropriate calibration, the probable range measurement accuracy is better than 3 meters (10 feet). A unique coding system is employed in the MRS III to minimize false range readings caused by radar interference and to provide selective reference station interrogation. The operating frequencies of the MRS III can be set (at the factory) above or below the operating frequencies of on-board radar systems to eliminate possible interference with normal radar operation.

1.2.4 U3 Uninterruptible Power Supply

The UPS unit contains a battery charger and a static inverter (see figure 1-5). In normal operation, the ac power is converted to dc power. The dc power from the charger supplies the inverter and maintains the batteries at full charge. The inverter changes the dc power back to ac and powers the critical load. When the ac line fails, the inverter continues to supply normal power to the load drawing power from the batteries. If an inverter malfunction occurs or the inverter is turned off, the load is automatically transferred to the ac bypass line.

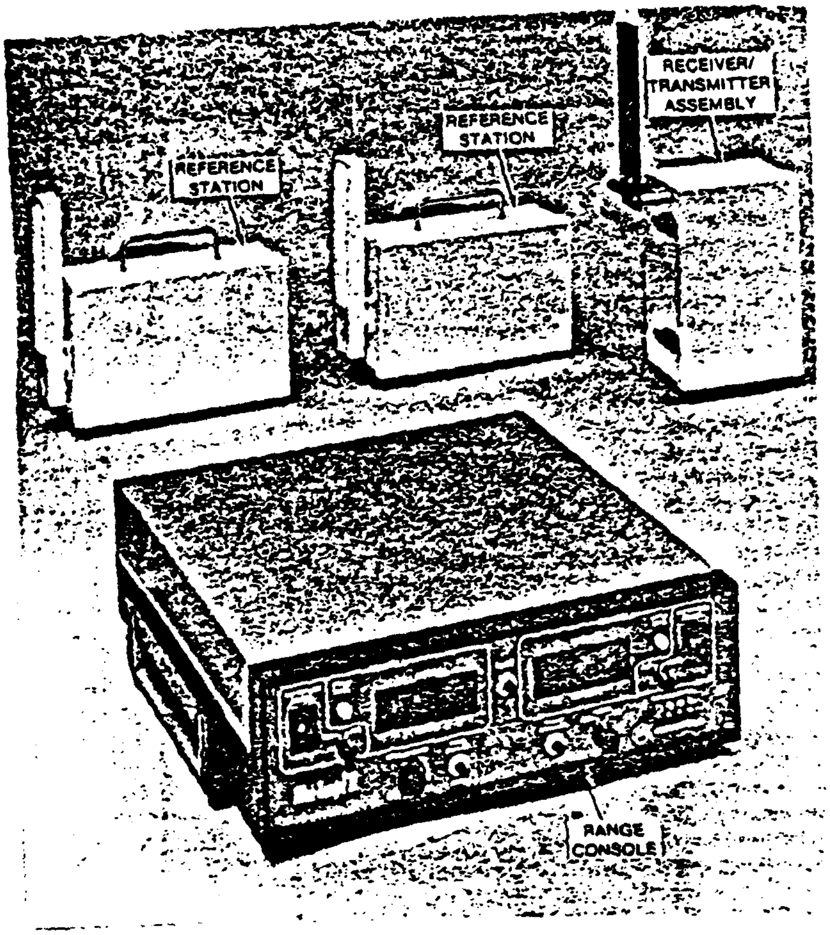


FIGURE 1-4 MINIRANGER III SYSTEM

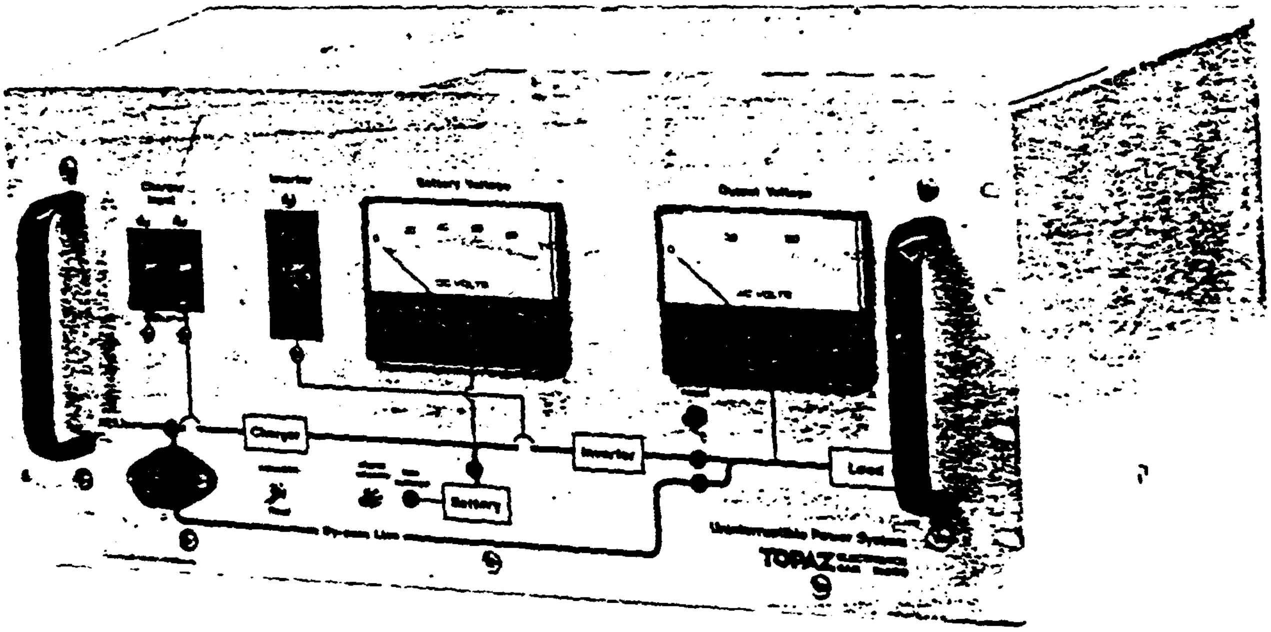


FIGURE 1-5 U3 UNINTERRUPTIBLE POWER SYSTEM

1.3 Equipment Specifications

1.3.1 AUSTRON 5000 Monitor System

- Antenna	8' whip
- Antenna Coupler	W0783
- Antenna Cable	RG-22
- NOTCH Filter	GCF-W-379-12A
- Receiver Power	
Voltage	115V $\pm$ 15V rms
Frequency	48 Hz to 420 Hz
Consumption	0.9 amp rms
- PDP-8/E Power	
Voltage	115 VAC
Frequency	60 Hz
Consumption	150 watts
- Weight	138 pounds
- Software Version	2/8/77

1.3.2 H/P 9845B Computer

- Memory	186K bytes
- ROMs	
I/O	98412A
Graphics	98411A
- Real-Time Clock	98035A
- Interfaces	
Serial I/O	98036A
BCD	98033A
16-Bit	98032A
- Power	
Voltage	108 to 126
Frequency	48-66 Hz
Consumption	275 va
- Weight	89.5 pounds

1.3.3 Mini-Ranger III System

- Range Console
- Receiver-Transmitter
- Two Remote Reference Stations
- Batteries (for each reference station)

- Power:	
Reference Station	24 to 30 VDC
Range Console	105 to 125 VAC
- Consumption:	
Reference Station	13 watts
Receiver/Transmitter	17 watts
Range Console	60 watts

1.3.4 Uninterruptible Power Supply

- Inverter	82102-12
- Two Battery Units	2566-2
- Voltage Monitor Panel	
- Power	105 to 130 VRM
- Weight	450 pounds

1.4 Reference Documents

1. AUSTRON Model 5000 Loran-C Monitor System Maintenance Manual, September 1977, P/N 12797049.

2. PDP-8/E Processor Maintenance Manual, Volume 1, No. EK-8E001-MM-004.

3. PDP-8/E Internal Bus Options Maintenance Manual, Volume 2, No. EK-8E002-MM-005.

4. PDP-8/E External Bus Operations Maintenance Manual, Volume 3, No. EK-8E003-MM-004.

5. PDP-8/E Engineering Drawings.

6. Hewlett-Packard System 45B Desktop Computer Operating and Programming Manual, Part No. 09845-91000.

7. Hewlett-Packard System 45B Desktop Computer Owner's Manual, Part No. 09845-91005.

8. Hewlett-Packard System 45B Desktop Computer Graphics ROM Programming, Part No. 09845-91050.

9. Hewlett-Packard System 45B Desktop Computer I/O ROM Programming, Part No. 09845-91060.

10. Hewlett-Packard System 45B Desktop Computer Quick Reference Manual, Part No. 09845-91015.

11. System 45B Asynchronous Terminal Emulator, Part No. 09845-10040.

12. Hewlett-Packard 98035A Real-Time Clock Installation and Operation Manual, Part No. 98035-9000.

13. Hewlett-Packard 98033A BCD Interface Installation and Service Manual, Part No. 98033-9000.

14. Hewlett-Packard 98032A 16-Bit Interface Installation and Service Manual, Part No. 98032-9000.

15. Hewlett-Packard 98036A Serial I/O Interface Installation and Service Manual, Part No. 98036-9000.

16. Maintenance Manual for Mini-Ranger III System (MRS III), Document No. 68-PØ4884F.

17. Operation and Installation Manual for Mini-Ranger III System (MRS III), Document No. 68-PØ4883F.

18. Uninterruptible Power Systems U3 Product Family Technical Manual, 933-LUØ63-TM Revision D.

19. State Plane Coordinates by Automatic Data Processing, U.S. Government Printing Office, Publication 62-4.

2.0 INSTALLATION

2.1 Field Installation of AUSTON 5000 Loran-C System

The Austron system console is best installed in the CPO quarters of a 65-foot tug and in the chartroom of an 180-foot buoy tender. This provides accessibility to the operator and is out of the way of the crew.

1. With all units removed mount the console to a secure platform.
2. Install the AUSTRON receiver in the console using the existing slides mounted in the top section of the console.
3. Install the PDP8/E unit into the existing slides mounted in the bottom of the console.
4. Secure the AUSTRON receiver with front panel screws.
5. Secure the PDP8/E with rubber strap or stretch cord.
6. Turn the console on/off switch to off.
7. Turn the PDP8/E on/off switch to off.
8. Connect the (3) data interconnect cables between the AUSTRON receiver and the PDP8/E. NOTE: THE CABLES ARE KEYED TO GO ONLY ONE WAY.
9. Check the (3) termination plugs on the AUSTRON receiver for tight connection.
10. Check jumper plugs J1, and J2 on the PDP8/E for tightness.
11. Mount the antenna coupler W0783 to a secure antenna platform or mast.
12. Screw in a 102 inch Loran-C whip into the coupler.
13. Connect antenna cable to the coupler.
14. Connect antenna cable to the AUSTRON receiver antenna connection.
15. Check circuit breaker and fuses on back of the PDP8/E.
16. Check fuses on the back of the AUSTRON receiver.
17. Connect AC jumper cable between AUSTRON receiver and PDP8/E.
18. Connect the AC input cable from PDP8/E to the AC outlet strip black terminal.
19. Connect the AC input cable to the voltage monitor panel outlet in the TOPAZ(UPS) console.

2.2 Field Installation of TOPAZ Uninterruptable Power Supply (UPS)

The (UPS) system is optional and its use will depend on the stability of the power source that will be utilized with the Austron system.

1. With all units removed except the voltage monitor panel, mount the TOPAZ console to a secure platform with angle iron and 1/4 inch bolts.
2. Install inverter and the (2) battery units into the console, with the inverter unit going on top.
3. Secure the units in with the front panel screws and the rear support brackets.
4. Install the jumper cable between the two battery units.
5. Connect the DC input cable to the inverter and the bottom battery unit.
6. Connect the AC input cable.

7. Plug in the voltage monitor panel cable into one of the inverter AC output sockets.
8. Check the battery unit fuses and the inverter unit fuse for proper value.

Fuse Specifications

Battery Unit - BAF 30
Inverter Unit - BAF 20

9. Plug the input AC cable into the isolation transformer.
10. With all switches off, plug the isolation transformer into the power source.

NOTE: CAUTION IS ADVISED AS INPUT 120 VAC IS DIRECTLY CONNECTED TO INPUT AND OUTPUT TERMINALS OF THE INVERTER WITH ALL SWITCHES OFF.

2.3 H/P 9845B Desktop Computer

The 9845B is best when installed in the pilothouse where visual and other navigational aids are present for assistance in surveying.

The standard 9845B does not come completely equipped with all the essential features needed to perform the Data Collection task. Several options are required to meet all specific tasks. (See Section 1.2.2.)

NOTE: Set Baud Rate desired on 98036A interface prior to operation.

CAUTION: ALWAYS SWITCH OFF THE COMPUTER WHEN INSERTING OR REMOVING ROMS AND INTERFACES. FAILURE TO DO SO COULD DAMAGE EQUIPMENT

2.4 System Interconnection

2.4.1 9845B to PDP8/E Data/Control Link

The interconnection between the 9845B Computer and the M8655 Control Card in the PDP8/E Computer is accomplished by use of a standard Digital Cable assembly (BC01V). Refer to PDP8/E Engineering Drawing for wiring specifications.

2.4.2 9845B to MRS III Control Link

The interconnection between the 9845B Computer and the Mini-Ranger III is accomplished by use of the standard H/P 98032A I/O interface which provides 16 bit data exchange. The wiring configuration used for the (TDSS) system is detailed in table 2-1. Refer to the Installation and Service Manual for the 98032A 16 bit interface for the technical specifications and operation description.

TABLE 2-1 - HP98032A 16 BIT INTERFACE

1J2	Ext Control	Wire Code
A	Spare	Not used
B	RT No. 1 & 2 off	Not used
C	Bite Normal	96 white/blue
D	Remote B-2	934 white/orange/yellow
E	Remote B-4	936 white/orange/blue
F	Remote A-1	90 white/black
G	Remote A-3	92 white/red
H	Remote B-1	97 white/violet
J	Remote B-3	935 white/orange/green
K	Nav xmit req	94 white/yellow
L	Remote A-2	91 white/brown
M	Ext sync	Not used
N	Remote A-4	93 white/orange
P	Xmit status	Not used
R	Radar blanking	Not used
S	Nav switch	95 white/green
T	+5 vdc	Not used
U	Micro switch	Not used
V	Ground	90 white

Tie the following wires to ground (white)

9 - white
- inner bare wire
903 - white/black orange

904 - white/black/yellow
905 - white/black/green
906 - white/black blue

Tie the following wires together

98 - white/gray
8 - gray

2.4.3 9845B to MRS III Data Link

The interconnection between the 9845B computer and the Mini-Ranger III is accomplished by use of the standard H/P 98033A BCD Interface which provides data transfer in bit-parallel and digit-parallel form. The wiring configuration used is detailed in table 2-2. Refer to the 98033A BCD Installation and Service Manual for the technical specifications and operations description.

TABLE 2-2 - H/P 98033A BCD INTERFACE

IJ5		On BCD Interface	Color
A	Spare		
B	Not used		
C	Not used		
D	Not used		
E	Not used		
F	Range A 10^0-1	923	white/red/orange
G	Range A 10^0-2	924	white/red/yellow
H	Range A 10^0-4	925	white/red/green
J	Range A 10^2-1	905	white/black/green
K	Range A 10^2-2	906	white/black/blue
L	Range A 10^2-4	907	white/black/violet
M	Range a 10^2-8	908	white/black/gray
N	Range A 10^3-1	901	white black/brown
P	Range A 10^3-2	902	white/black/red
R	Range A 10^3-4	903	white/black/orange
S	Range A 10^3-8	944	white/black/yellow
T	Not used		
U	Not used		
V	Not used		
W	Not used		
X	Ext Hold	8	Gray
Y	Not used		
Z	A-BCD Flag	918	white/brown/gray
a	Range A 10^0-8	926	white/red/blue
b	Range A 10^1-1	912	white/brown/red
c	Range A 10^1-2	913	white/brown/orange
d	Range A 10^4-1	94	white/yellow
e	Range A 10^4-2	95	white/green
f	Range A 10^4-4	96	white/blue
g	Range A 10^4-8	97	white/violet
h	A Code ID 1	945	white/yellow/green
i	A Code ID 2	946	white/yellow/blue
j	A Code ID 4	947	white/yellow/violet
k	Ground		
m	+5 volts		
n	Range A 10^1-4	914	white/brown/yellow
p	Range A 10^1-8	915	white/brown/green
q	Range A 10^5-1	90	white/black
r	Range A 10^5-2	91	white/brown
s	Range A 10^5-4	92	white/red
t	Range A 10^5-8	93	white/orange

Tie the following wires to ground

0 - black	916	white/brown/blue
1 - brown	917	white/brown/violet
2 - red	937	white/orange/violet
3 - orange	936	white/orange/blue
4 - yellow	935	white/orange/green
5 - green	934	white/orange/yellow
6 - blue	927	white/red/violet
7 - violet	948	white/yellow/gray

Tie the following wires together

98 - white/gray
928 - white/red/gray

2.4.4 Antenna Cable

The connection between the W0783 Antenna Coupler and the AUSTRON 5000 is accomplished by use of a standard RF TWINAX Cable (BELDEN 9250) RG-22 B/U. (See appendix K for connector phasing.)

2.5 System Initialization

Before operation, the system should be installed in accordance with section 2.

Preliminary Steps:

A. Set Band rate on 98036A Serial I/O Interface to 9600. The bit rate can be set (through the hole on the side) without disassembling the interface. Set the bit rate switch to correspond to the bit rate of the data communications device connected to the interface. Here is a list of the available bit rates and switch positions to select each rate. Rotate the switch to the desired position with a small screwdriver.

Switch Position	Bit Rate	
1	9600	Use 1/16 Bit Rate Factor (bits 0 and 1 of mode word)
2	4800	
3	2400	
4	1800	
5	1200	
6	600	Use 1/64 Bit Rate Factor (bits 0 and 1 of mode word)
7	300	
8	150	
9	75	

B. Set switches on the PDP8/E M8655 Asynchronous Data Control Card to match the 98036A Serial I/O Interface. The KL8-JA (M8655) Asynchronous Data Control Card is provided with two dual in line switches for setting the device code and transmission speed. The switches are located in the lower right hand corner. They are labeled transmit and receive.

The bit assignments for the switches are as follows:

Table 2-3. KL8-JA (M8655) switch settings

SPEED SELECTION

110 Baud Rate

Transmit Switch#		Transmit Position	Receive Switch#		Receive Position
1	=	off	1	=	off
2	=	off	2	=	off

300 Baud Rate

Transmit Switch#		Transmit Position	Receive Switch#		Receive Position
1	=	off	1	=	off
2	=	off	2	=	on

9600 Baud Rate

Transmit Switch#		Transmit Position	Receive Switch#		Receive Position
1	=	on	1	=	on
2	=	off	2	=	on

DEVICE CODE SELECTION
Master Control

Transmit Switch#		Transmit Position	Receive Switch#		Receive Position
3	=	off	3	=	off
4	=	off	4	=	off
5	=	off	5	=	off
6	=	on	6	=	off
7	=	off	7	=	on
8	=	off	8	=	on

2.5.1 Turn-On Procedure

2.5.1.1 TOPAZ (UPS) System (Optional)

1. Set CHARGER INPUT circuit breaker to the UP/ON position.
2. Set the INVERTER circuit breaker to the UP/ON position.
3. Push the RESET button to shift from AC bypass to inverter output.

NOTE: The lights should shift from red (AC bypass) to green (inverter) output line.

4. Check voltage monitor panel for proper readings:
   - 60 HZ
   - 5 amps input with batteries at full charge (81 VDC) and no load condition.
   - 5-10 amps with batteries on charge, no load condition.
   - 5-20 amps with batteries on charge and under load.

2.5.1.2 AUSTRON 5000 System

1. Set console ON/OFF switch to ON
2. Insert key in PDP8/E OFF/POWER/PANEL LOCK switch then turn to POWER position.
3. Let system warm up for 15 minutes before loading any instructions into the PDP8/E.

2.5.1.3 HP9845B Computer

Turn on the system 45B by pressing the power switch on the right-hand side of the computer. Memory is tested automatically and "9845B IS READY FOR USE" will be displayed on the CRT when all tests are completed.

2.5.2 Bootstrap Programming the PDP8/E

1. First, insure that the computer is not "RUNNING" any programs by first depressing, then raising the "HALT" switch.
2. Set selector switch to the "MD" position.
3. LOAD THE EXTENDED MEMORY ADDRESS (EMA) by setting the switch registers (SR) to field (0000), then depressing the "EXTD ADDR LOAD" switch.
4. Next, check the validity of the setting by observing the EMA lamps, they should be out.
5. Load the starting address (0030) by setting the required SR switches, then, depressing "ADDR LOAD". Again check the validity with the address lamps.
6. Once the proper starting address has been established, the loading of the BOOTSTRAP may begin. Set the contents of the first address on the proper SR's as designated by the BOOTSTRAP (table 2-4).
7. Lift the "DEPOSIT" switch once, and only once, this will insert the contents into the address and automatically increment the address to the next address.
8. After loading the last content of the BOOTSTRAP, it is advantageous to check the contents of the addresses for errors. This is accomplished by, returning to the starting address (0030), and depressing the "EXAM" switch for each address.
9. Observe the memory address lamps and check to see that they agree with the contents of the first address; if they do, continue this procedure until the entire program has been checked.

10. Upon completion of the checks, return to starting address (0030).
11. Set the SELECTOR switch to the "STATUS" position.
12. Go to 2.5.3.

TABLE 2-4. BOOTSTRAP PROGRAM

Field 0	Location	Contents
	0030	7421
	0031	6032
	0032	6031
	0033	5032
	0034	6034
	0035	7010
	0036	7701
	0037	7004
	0040	7420
	0041	5030
	0042	3000
	0043	2042
	0044	5030

2.5.3 Loading the AUSTRON 5000 Program

1. Load the bootstrap program as per section 2.5.2.
2. Check for validity and return to address 0030.
3. Place the SURVEY program tape into the 9845B tape drive (T15).
4. Type: LOAD "LOAD96:T15"
5. Press: EXECUTE

NOTE: Read steps 6-10 before proceeding.

6. When system-busy (RUN light) goes out press: RUN
7. When 3 beeps are heard depress the "CLEAR" then "CONTINUE" switch on the PDP8/E. (You have 10 seconds before program starts to load)
8. Observe run light and address lamps on PDP8/E. After a few seconds, the address lamps should indicate 7675.
9. The PDP8/E addresses read 7777 and the RUN light is out when the program is loaded.
10. The program takes approximately 30 seconds at 9600 baud and 12 minutes at 300 baud.
11. On PDP8/E load address 0200 after program is loaded.
12. Return to 9845B and place "SURVEY" program tape into tape drive (T15).
13. Type: LOAD "SURVEY:T15"
14. Press: EXECUTE
12. When system busy light goes out, press: RUN
13. "RUNNING" will appear in the display area on the CRT.
14. Return to PDP8/E and depress: CLEAR then CONT switch.

15. If the program has been loaded into the AUSTRON correctly the following will appear in the display area o f the 9845 CRT.

    AUSTRON SYSTEM 5000
    LORAN-C MONITOR TEST VERSION 2/8/77

16. Press: SFK #8 (on-KBD)
17. "TELETYPE ON" will appear in display area
18. At this time, the Loran-C chain should be initialized using the AUSTRON 5000 system commands (appendix A).
19. To transmit each command to the AUSTRON follow the below procedure.
    a. Type: Command you want to send i.e., DEF99600
    b. Press: EXECUTE
    c. The command will appear on the display as it is echoed back from the AUSTRON
    d. At this point, set the following: Clip, Date, Time, TMCN (before TMCN is entered, go off keyboard and enter DEBUG), etc.
    e. When the AUSTRON is initialized and no more commands need to be sent depress SFK#4 (OFF-KBD).

20. When all Loran-C stations are locked on and tracking (AT) a report will appear in the display area in the following format:

TABLE 2-5. AUSTRON REPORT

063 07:38:44 CHAIN 1

M	AT	071	0015	02.94	36568.37	
W	AT	088	0372	02.93	51268.20	14699.83
X	AT	060	0000	02.92	62704.05	26135.67
Y	AT	082	0093	03.00	80563.86	43995.48
Z	AT	096	0442	03.05	96703.73	60135.35

21. When all necessary stations are tracking you may begin data collection

3.0 SYSTEM OPERATION

This section provides a description of the operation of the TDSS. The following paragraphs assume that the TDSS has been installed and the AUSTRON 5000 program has been loaded into the PDP8E (see section 2). Operation of the TDSS is broken down into three subsections:

a. 3.1 Start-Up
b. 3.2 AUSTRON 5000 Control
c. 3.3 Data Collection

3.1 Start-Up

The general turn-on procedure is to load the program "SURVEY" into the HP9845 and then start up the AUSTRON 5000 and Mini-Ranger. It is assumed that the AUSTRON 5000 software is loaded into the PDP8-E memory. If not, see Section 2 before proceeding further.

3.1.1 HP9845

- Turn power on
- Install "SURVEY" program cartridge in "T15"
- Load "SURVEY" Program
- RUN

3.1.2 AUSTRON 5000 SYSTEM

- Turn power on
- Allow 15 minutes warmup
- Start PDP-8 at Address 400
- Set AUSTRON using commands (see appendix A)
  CLIP - 130
  TMCN's - 50
- Set receiver to track all 5 stations (M,W,X,Y,Z)
- Press Debug SFK #27 - set only once after initial loading of AUSTRON Program into PDP8-E

3.1.3 Mini-Ranger

- Turn power on
- Control settings for range console
  Channel A - EXT, REF 1
  Channel B - INT, REF 1
  Display Rate - 060 degrees
  NAV switch - NAV

3.2 AUSTRON 5000 Control

The AUSTRON 5000 is controlled by using several 9845B special function keys (see figure 3-1) or by setting the HP9845 in the "teletype mode" and using the standard AUSTRON 5000 commands.

SPECIAL FUNCTIONS — MASS STORAGE IS

S	GRAPHICS	DUMP GRAPHICS	ACQ1	RPRT1	TMCN	Data-Call	:T14	:T15
	K0	K1	K2	K3	K4	K5	K6	K7
	PRINTER 0	PRINTER 16			OFF Kbd		REWIND T14	REWIND T15
S		STRT	STOP	DEBUG	STATS	SIGN1		
	K8	K9	K10	K11	K12	K13	K14	K15
	On-Kbd	PAUSE	CONT			EDIT LINE	LIST	

NOTE:
S = SHIFT KEY HELD PRIOR TO PRESSING S FUNCTION KEY, WHICH IS KEYS K16→K31

FIG 3-1 SPECIAL FUNCTION KEY OVERLAY

3.2.1 AUSTRON 5000 Related Special Function Keys (SFK's)

RPRT1 - Transmits a "RPRT1" message to the AUSTRON 5000
- Press: K19
- "RPRT1" followed by RPRT message will be printed on the CRT or hard-copy printer

ACQ1 - Transmits a "ACQ1" message to the AUSTRON 5000
- Press: K18
- Begins coarse acquisition on chain 1 with a gain level of 96 db

TMCN - Transmits a "TMCM" message to the AUSTRON 5000
- Press: K20
- This command requires the operator to input the TMCN desired

3.2.2 Standard AUSTRON Commands

The HP9845 keyboard is configured in the teletype mode by executing the ON-KBD special function key (K8). Commands to the AUSTRON are entered via the keyboard as if it were a teletype (see appendix A for command dictionary). The EXECUTE, CONT, or RUN key is equivalent to a carriage return. When the keyboard is in the teletype mode, the only special function key active is OFF-KBD (K4).

- Press: K8 (ON-KBD)
- "TELETYPE ON" appears on the display line
- Enter: AUSTRON 5000 command
- Press: EXECUTE, CONT, or RUN

The command and AUSTRON 5000 response is printed on the CRT or hard-copy printer.

To exit teletype mode:

- Press: K4 (OFF-KBD)
- "TELETYPE OFF" appears in the display line

3.3 Data Collection

Data collection of both Mini-Ranger and Loran-C data or Loran-C data only is initiated and controlled by special function keys:

Data Col (K21) - Data collection initialization. The type of data to be collected (TD only or TD and Mini-Ranger), sample rate, and data display are selected. Start and Stop are enabled. If a graphics display is chosen, the display is initialized.

Start (K25) - Data collection start. Starts the data collection sequence. Samples are printed on the hard-copy printer and selected data is plotted on the CRT.

Stop (K26) -	Data collection stop. (Do not confuse with a program STOP.) Data collection sequence is stopped. The graphics display is dumped onto the hard-copy printer and a statistics summary table is printed on the hard-copy printer.
Stats (K28) -	Prints interim cumulative statistics calculations on demand.
Sign (K29) -	Inverts trilateral triangle when calculating position from Mini-Ranger data. Used when Mini-Ranger baseline is crossed during data collection.
Pause (K9) -	Data collection pause. (Do not confuse with a program PAUSE.) Data samples are not stored or displayed on graphics. AUSTRON 5000 reports are printed on CRT.
Cont (K10) -	Data collection continue. (Do not confuse with program CONT.) Cancels Pause commands.

3.3.1 Data Collection User Instructions

3.3.1.1 AUSTRON 5000 Setup. The AUSTRON 5000 must be configured to track one chain with five stations. TMCN, CLIP, and TIME should be checked and reset if necessary. A TMCN of 50 and a CLIP level of 130 is recommended for all five stations. The master and secondaries of interest must be in the track mode. Other secondaries may be "killed" using the AUSTRON STOP command.

3.3.1.2 Initialization. Press K21. The following information is requested:

REQUEST	RESPONSE
Sample Period?	Period in seconds, should be greater than 2 x TMCN/10
Use MRS III?	Y or N
Graphics plot?	Y or N
Reference station name?	File name, be sure tape is in "T15"
Transponder location?	B or C
Ranges to transponder 1 and 2?	Ranges in KM
Use present graphics parameters?	Y or N
Graphics parameters?	X-AXES, Y-AXES, X-MIN, X-MAX, Y-MIN, Y-MAX, X-Predicted, Y-Predicted, SLOPE
Type plot?	1, 2, or 3
CT/AT plot parameters?	X, Y starting, X, Y stopping
XY plot parameter	X, Y coordinates, operating range (KM)
Press START when ready?	Hit START

NOTE: For SFK control explanation, see section 4.1.2.

4.0 SOFTWARE

4.1 "SURVEY" Program Description

The program "SURVEY" consists of a main operating program and a set of modular subroutines and subprograms which allow the user to control an AUSTRON 5000 Loran-C Receiver and to sample, process and display data from an AUSTRON 5000 (date/time, four TDs) and a Motorola Mini-Ranger (two ranges). The program responds to interrupts and flags generated by special function keys, I/O interfaces, the keyboard.

The program "SURVEY" evolved from the 9845A Terminal Emulator program "LTMIN" and an early data collection program which did not provide the capability to control the AUSTRON 5000. The inability to control the AUSTRON with the HP9845 resulted in an additional terminal and added operational complexity. The current program provides a convenient easy to use data collection system with minimum components.

Figure 4-1 is a block diagram of the survey program and figure 4-2 is a flow chart of the main operating program. After initialization, the main operating program cycles through a loop checking for the following (see figure 4-2):

a. Is the AUSTRON 5000 program patch to be inserted?
b. Is the keyboard to be switched from the teletype to the calculator mode?
c. Has a message been received from the AUSTRON 5000?
d. Is there a message to be transmitted to the AUSTRON 5000?
e. Is a data collection run complete?

NOTE: The AUSTRON 5000 program patch is only inserted once after the AUSTRON 5000 program is loaded into the PDP-8E.

End-of-line branches to subroutines and subprograms are directed by special function keys, the RS-232 interrupts, the real-time clock, and the keyboard (teletype mode, i.e., on KBD active). Special function key interrupts are used to:

a. initialize data collection
b. start, pause, continue, and stop data collection
c. print statistics (intermediate results)
d. switch the keyboard to the teletype mode
e. generate AUSTRON 5000 commands: RPRT1, TMCN, ACQ1

Interrupt service routines handle:

a. data input from the AUSTRON 5000
b. keyboard interrupts (teletype mode)
c. real time clock interrupts

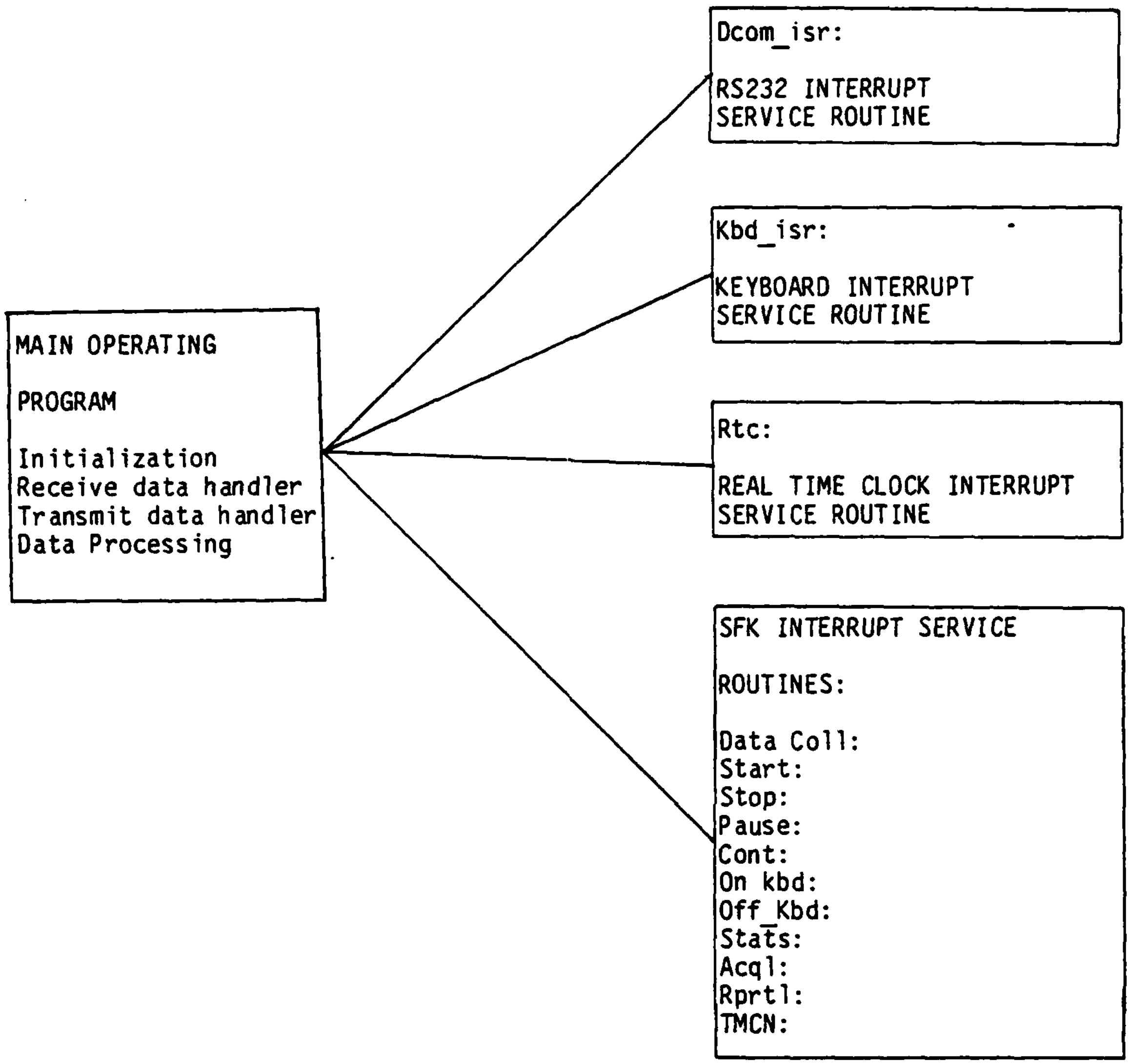


FIGURE 4-1. DATA-COLLECTION PROGRAM BLOCK DIAGRAM

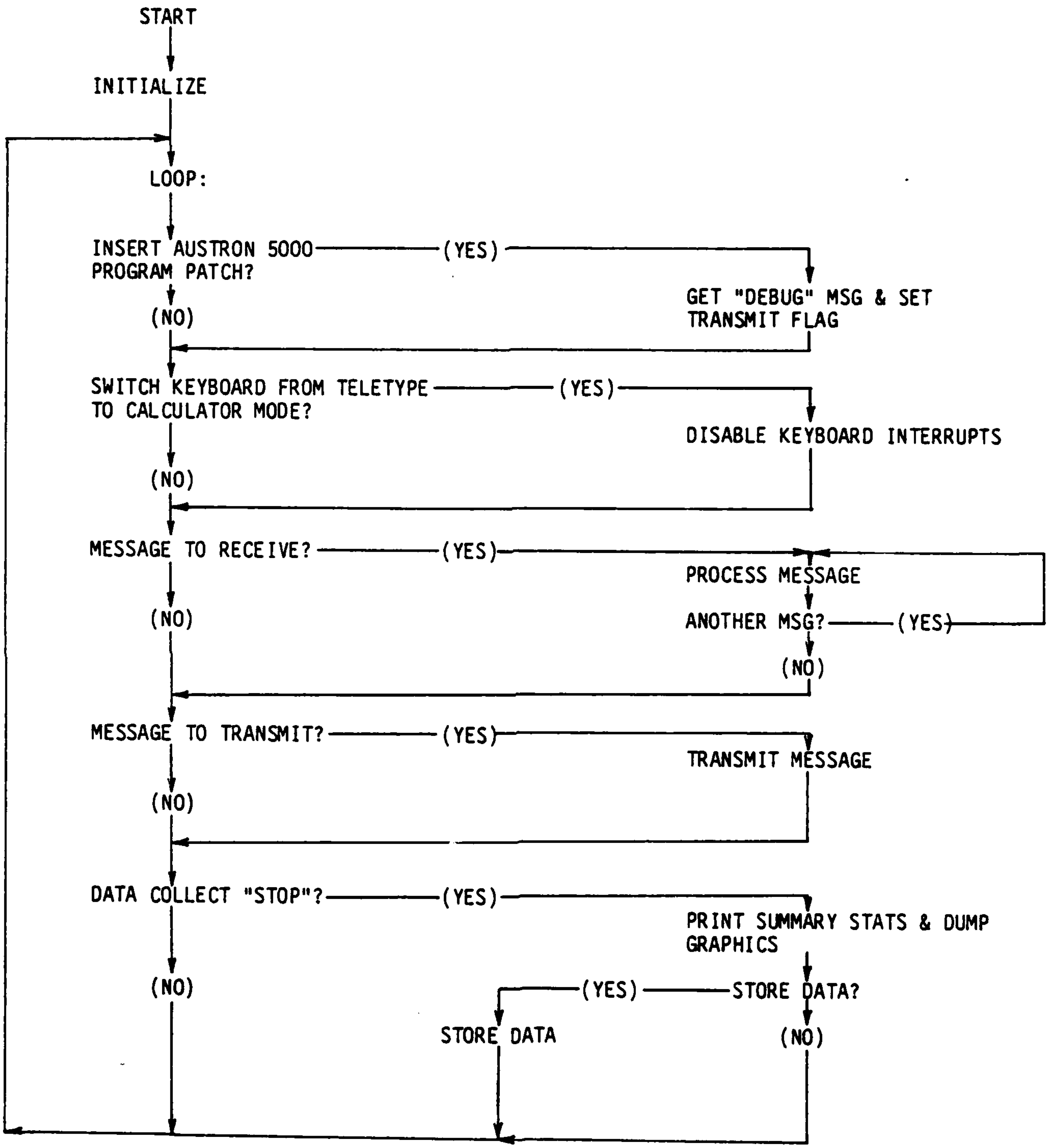


FIGURE 4-2. MAIN OPERATING PROGRAM FLOW CHART

4.1.1 Main Operating Program

The main operating program is divided into four sections:

a. initialization
b. receive data handler
c. transmit data handler
d. data processing

Each of these sections and the subprograms used in each section are described in the following paragraphs. More detail on the subprograms is provided by annotations in the program listing found in appendix D.

4.1.1.1 Initialization (See figure 4-3)

The initialization sequence of the program:

a. Defines and dimensions common variables (option base 1)
b. Dimensions program arrays (option base 1)
c. loads SFK typing aids, e.g., "PRINTER IS 16", "PRINTER IS 0", "DUMP GRAPHICS", etc.
d. Initializes program variables
e. Defines SFK interrupts (see SFK Interrupt Service Routines)
f. Sets up the RS232 interface variables between the HP9845 and Austrom 5000
g. Opens the communications channel (RS232) between the HP9845 and AUSTRON 5000 (see Data Communications Interrupt Service Routine)
h. Assigns Unit 2 of the Real Time Clock to output port 2

Subroutines and subprograms used in the initialization sequence are:

SFK: This "SFK" program loads the SFK execution command aids used in the program.

Keys: This subroutine defines the end-of-line branches for SFK interrupts.

Dcom-Setup (Err): This subprogram sets up the 98036 card on the select code passed in through the COM statement (220). If Err is set to 1 upon exiting the subprogram, then the communications link was not established. To change the parameters of bit rate factor, parity, stop bits and bits per character, refer to the 98036A manual concerning the R4C mode word.

INITIALIZATION:

(200) SET OPTION BASE 1

↓

(210) DEFINE MASS STORAGE AS ":TI5"

↓

(220) DEFINE AND DIMENSION COMMON VARIABLES

↓

(230) DIMENSION PROGRAM ARRAYS

↓

(340) LOAD SFK DEFINITIONS

↓

(360) DEFINE SFK INTERRUPTS

↓

(370) INITIALIZE VARIABLES

↓

(470) SET UP RS232 INTERFACE

↓

(490) OPEN RS232 COMMS CHANNEL

↓

(500) SET UNIT 2 OF REAL TIME CLOCK TO OUTPUT PORT 2

FIGURE 4-3. INITIALIZATION

Dcom_Err: This subroutine prints an error message indicating problems in establishing the RS232 communications link.

Dcom_isr: This subprogram is the data comm interrupt service routine. It monitors the channel between the HP9845 and AUSTRON 5000 and constantly processes characters as they come in. Get_data (B$, prompt) acts as a front-end for this routing (see Receive Data Handler).

Debug (A$, Bug $(*), Bug_com, Bug_count): This subprogram is implemented in the program's main operating loop but is listed here since it is an initialization function. The subprogram loads the AUSTRON program patch step by step into A$ from Bug $(*) until the program modification is complete. When the line counter Bug_ count reaches the last line, the flag Bug_com is reset.

4.1.1.2 <u>Receive Message Handler</u> (See figure 4-4)

Data messages from the AUSTRON 5000 are stored in a circular buffer, DCOM$. (See Dcom_isr Interrupt Service Routine). The receive message handler checks for a message by detecting a start-of-header (SOH) or carriage return (CR) character in DCOM$ (see Get_data (B$, Prompt)). Messages starting with a SOH character are strip chart data which the program removes from DCOM$ and ignores. If the message is a teletype message (CR detected) and data is not being collected the message is printed (default to CRT). In the data collect mode, the program looks for a "RPRT1" message. Date, time and TDs are stripped from each RPRT1 message received (see Data Processing). If master is not in the track mode, the sample is aborted. The RPRT is printed on the CRT if the program is in the data collect "pause" mode. Messages other than RPRT are printed on the hard copy printer (CRT during "pause"). After a message is received the program checks for another message in DCOM$ before continuing to the transmit data message handler.

Subroutines and subprograms used in the receive message handler are:

FNDc_ready: This function returns a 1 when a carriage return (CR) or start of header (SOH) is detected in the data comm buffer, DCOM$.

Get_data (B$, Prompt): This subprogram gets a line of data (B$) received from the AUSTRON 5000. The variable Prompt indicates what type of data has been received. A 1 is returned if B$ is a teletype message. A 2 indicates a complete strip chart message (10 characters). An incomplete strip chart message (less than 10 characters) returns a 3.

4.1.1.3 <u>Transmit Message Handler (See figure 4-5)</u>

Messages to the AUSTRON 5000 are generated by keyboard entries (teletype mode), special function keys (TMCN, RPRT1, ACQ1), and data sample requests (see Rtc Interrupt Service Routine). The transmit message handler checks if a message has been generated from any of the above sources. Messages are transmitted character by character with a 60 ms delay

RECEIVE MESSAGE HANDLER:

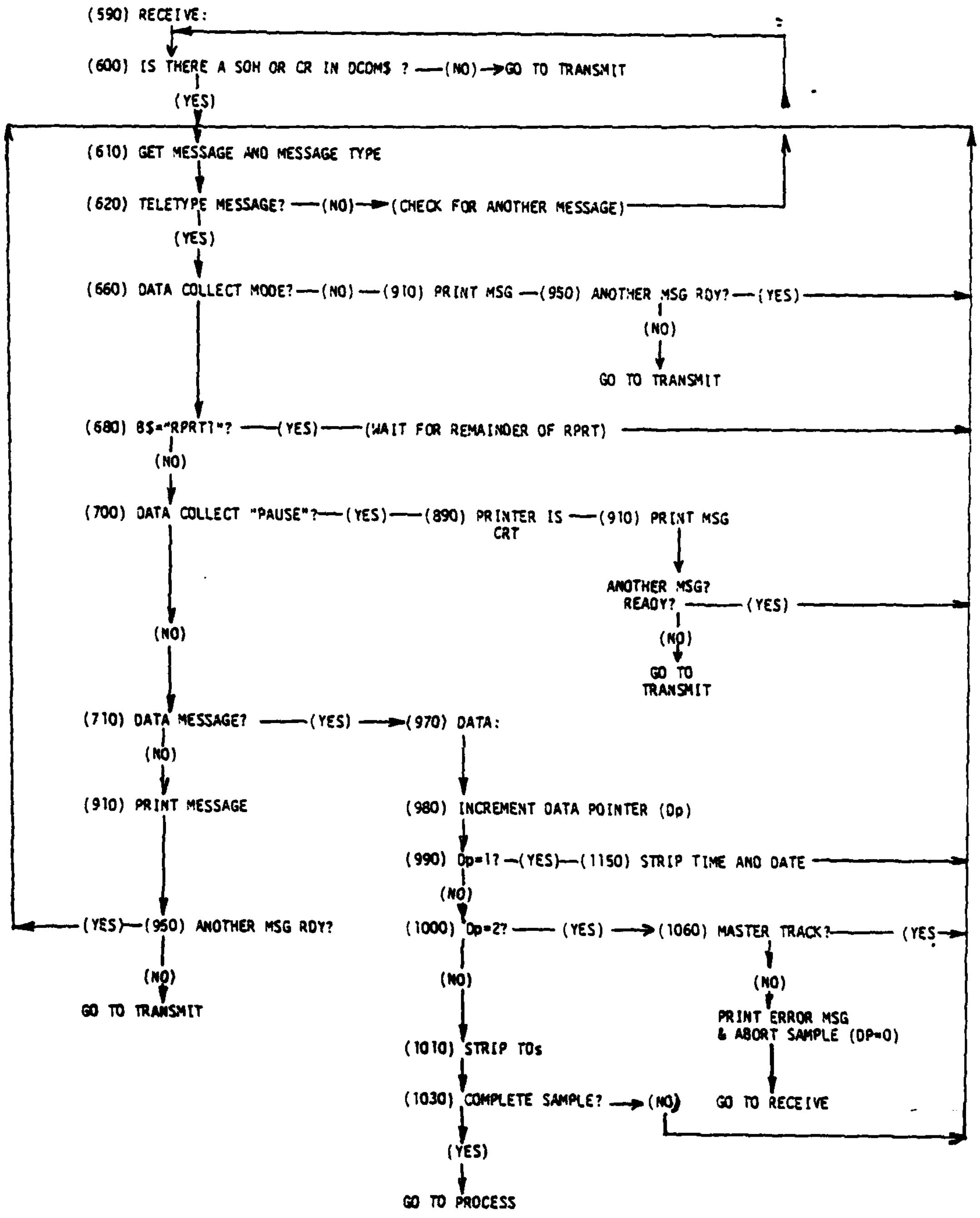


FIGURE 4-4. RECEIVE MESSAGE HANDLER

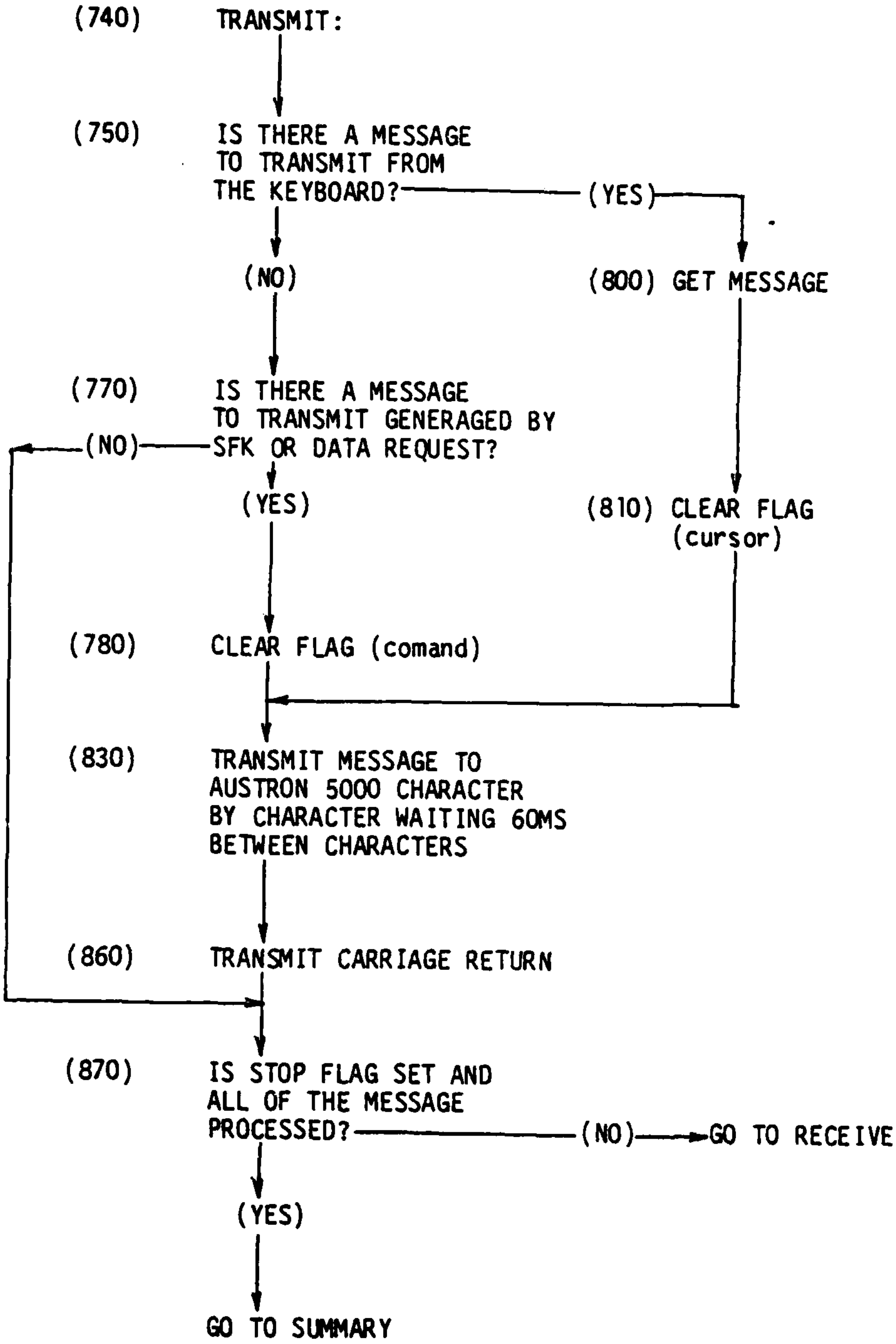


FIGURE 4-5. TRANSMIT MESSAGE HANDLER

between characters followed by a carriage return. The delay between characters is necessary to insure that the AUSTRON 5000 will consistently receive the entire message.

Subroutines and subprogram used in the transmit message handler are:

FNKbd_ready: This function returns a 1 if CONT, STORE, EXECUTE, or SFK 4 was hit and the program is the teletype mode. It indicates a SEND command when CONT, EXECUTE, or STORE are hit. It switches out of teletype command when SFK 4 is hit. Hitting SFK 4 also causes the COM variable Kbd to equal 0.

Get_line (A$): This subroutine gets a line generated from the keyboard in the teletype mode to be transmitted to the AUSTRON 5000.

4.1.1.4 Data Processing (See figure 4-6)

Data samples consist of date/time, four TDs, and two Mini-Ranger ranges (optional). Up to 400 samples may be stored during a data collection run. If 400 samples are reached, the program automatically stops data collection. The samples are stored in sets of 100 to minimize magnetic tape storage requirements. If Mini-Ranger data is collected, the program computes the vessels xy position. Along and cross track distances are also computed if they are to be displayed. Each data sample and computed position (if Mini-Ranger data is sampled) is printed on the hardcopy printer. Cumulative statistics for each TD (mean, standard deviation) are calculated after each sample. Covariance, correlation coefficients, and regression line slope are also calculated after each sample for each TD pair (wx, wy, wz, xy, xz, yz). Three graphic plots are available (TD, xy, cross track/along track). The plot desired is chosen by the operator during data-collect initialization (see Data_Coll Interrupt Service Routine). The operator also has the option of no graphic display.

At the end of a data collection run, the graphics plot is dumped onto the hardcopy printer and a summary statistics tabulation is printed. The operator is then given the option to store the data on magnetic tape. All program-related files are stored and retrieved from the right-hand tape drive while data is stored using the left-hand drive.

Subroutines and subprograms used in the data processing section of the program are:

Triangle (Ra, Rb, Rc, A, B, C) - This subprogram computes the angles of a triangle (A, B, C) given the three sides (Ra, Rb, Rc) using the law of sines. Ra is the baseline length between reference stations; Rb and Rc are measured ranges. (See appendix G.)

Position (Zo(*), Alpha, Rc/1000, Sign, B, Z(*)) - This subprogram computes the position of the vessel, Z(*), from Mini-Ranger data. (See appendix G.)

(1190) PROCESS:

(1210) INCREMENT SAMPLE COUNTER

(1300) SAMPLE NO = 400? —(YES) —STOP DATA COLLECTION

(NO)

(1330) PRINT SAMPLE

(1390) STORE DATA IN SETS OF 100

(1720) COLLECTING MINIRANGER DATA? —(NO)

(YES)

(1800) CALCULATE POSITION

(1820) PLOTTING ALONG/CROSS TRACK? (NO)

(YES)

(1850) CALCULATE ALONG/CROSS TRACK

(1890) CALCULATE CUMMULATIVE STATS
(if collecting miniranger data substitute
x&y for TDW and TDZ (1830)

(1900) CALCULATE CUMMULATIVE REGRESSION COEFFICIENTS

(1910) COLLECTING MINIRANGER DATA? —(NO)

(YES)

(1930) PRINT RANGES, ANGLES, X/Y, CT/AT

(1940) STOP? —(YES) — RESET DATA COLLECT FLAG

(NO)

(1950) PAUSE? —(YES) —GO TO TRANSMIT

(NO)

(1960) PLOT DATA? —(NO)—GO TO TRANSMIT

(YES)

(1990) PLOT DATA

FIGURE 4-6. DATA PROCESSING

Stats (Td(*), Sample, Stats(*), Cov(*), O-Set(*)): This subprograms computes cumulative statistics for four variables, Td(*). The array Stats(*) contains the cumulative sum, sum of squares, average and standard deviation for each variable minus the offset (O-set(*)). The array Cov(*) contains the sum of cross products, covariance and correlation coefficient for each pair of variables minus the offset (O-set(*)). The array O-set(*) is the offset (i.e., the first sample) subtracted from each sample to prevent computational errors. (See appendix H.)

Reg (Stat(*), Cov(*), S(*), R(*), O-Set(*)): This subprogram computes linear regression parameters for each pair of four variables. Inputs to the program are the statistics arrays generated by the Stats subprogram (Stats(*), Cov(*), and O-set(*)). The array S(*) contains a summary of the statistics for each pair of variables (mean and standard deviation). The array R(*) contains the regression line slope, the standard deviation of the residuals, and the variable chosen as the independent variable for each pair of variables. The program picks the variable with the larger standard deviation as the independent variable for calculating linear regression parameters. (See appendix I.)

Disp-run (Td(*), Sample, Xmn, Xmx, Ymn, Ymx, Mp, X axes, Y axes, Prx, Pry, Cba, Lcb, Cbb, Cbc, Lcb2, Lcb3, Stp, R(*)): This subprogram provides a real time TD/TD plot and bar graph of regression line residuals. Variable selection and graph parameters are input during data collect initialization (see Data-Coll Interrupt Service Routine). The program also allows a predicted regression line to be displayed for comparison with data collected.

Plot-ct (Ct, At, Rdist, Sample): This subprogram provides a real time display of vessel cross track (Ct) and along track (At) position. Track end points are input during data collect initialization.

Plot-xy (Sample, Wp-x, Wp-y, Z(*), Op r): This subprogram provides a real time display of vessel position. Display origin (Wp_x, Wp_y) and anticipated operating range (Op_r) are input during data collect initialization.

Summary: This subroutine dumps the graphics display onto the hardcopy printer and prints a summary statistics table. Certain program parameters are zeroed during this routine and the operator is given the option to store the data on a magnetic tape cartridge.

Create: This subroutine creates and stores data on a data file large enough to accomodate the number of data samples collected. Data is stored in sets of 100 to reduce file size requirements.

4.1.2 Special Function Key Interrupts

There are two general sets of SFK interrupts in the program "SURVEY". One set implements data collection functions. The other set is used to control the AUSTRON 5000 receiver. (See figure 3-1.)

4.1.2.1 Austron 5000 Receiver Control

The SFK "ON KBD"(#8) converts the keyboard of the HP9845 to the teletype mode. Keyboard strokes are stored in a buffer (Buf$). Hitting the EXECUTE, STORE, or CONT key causes the contents of Buf$ to be transmitted to the AUSTRON 5000. SFK "OFF KBD"(#4) returns the keyboard to the calculator mode.

SFKs ACQ1(#18), RPRT1(#19), and TMCN(#20) cause the corresponding commands to be transmitted to the receiver. The TMCN command requires the operator to input the TMCN desired.

The following subprograms and subroutines are utilized to implement receiver control functions:

ON-Kbd (2400). This is the service routine for SFK#8 "ON KBD". It executes the ON KBD statement and sets Kbd = 1. Kbd-isr is the ON KBD service routine.

Kbd_isr (4980). This subprogram is the keyboard service routine. It is responsible for acting upon keystrokes entered by the user. This routine defines SFK#4 (OFF KBD) to reset the flag, Kbd, which causes a branch to the Off-kbd routine in the main operating program. Note: All other keyboard interrupts are inactive with the keyboard in the teletype mode. The subprogram Get_line (A$) acts as a frontend to this routine.

Get_line(A$) (5670). This subprogram gets a line from the keyboard into A$. The line is then transmitted to the AUSTRON 5000. See the Transmit Data Handler section.

FNKbd_ready (6250). This function returns a 1 if CONT, EXECUTE, STORE, or SFK#4 (OFF-KBD) was hit. CONT, EXECUTE, or STORE initiate a transmit command. SFK#4 switches the keyboard back to the calculator mode.

Off-Kbd (2440). This is the service routine for SFK#4(OFF-KBD). It switches the keyboard from the teletype to the calculator mode by executing the OFF KBD command and sets Cursor=1 (cancels the transmit command).

RPRT1 (2260), ACQ1 (2200). These routines service SFKs #19 and #18 respectively. "RPRT1" or "ACQ1" are loaded into the transmit variable A$ and the transmit flag, "Comand," is set.

TMCN (2310). This routine loads the TMCN command for each station into the transmit variable A$ and sets the transmit flag, Comand. The routine requests the desired TMCN and sets all stations to the same value.

Debug (4870). This routine inputs the program patches into the AUSTRON 5000 that are necessary to modify the system for use in an aircraft or vessel.

4.1.2.2 Data Collection Functions

The following data collection functions are implemented using SFK interrupts:

a. data collection initialization
b. data collection start
c. data collection stop
d. data collection pause
e. data collection continue
f. print data statistics
g. change Mini-Ranger fix geometry

Initialization (SFK#21). Data-coll (2500) is the data collect initialization service routine for SFK#21, DATA_COL. Figures 4-7A and 4-7B contain the flow chart for Data_coll. The main functions of this routine are to initialize variables, set the data sampling period, input Mini-Ranger reference station data (if being used), and initialize the graphics plot (if data is to be plotted). The routine is bypassed if the program is already in the data collect mode.

The program assumes Mini-Ranger reference station numbers 1 and 2 are being used. If another pair is used, line 2640 must be changed to indicate the proper status.

Data Collection Start (SFK#25). Start (3640) is the data collect service routine for SFK#25, START. The routine is bypassed and an error message displayed if the program is already in the data collect mode or data collection has not been initialized. The routine sets up a real time clock interrupt branch and sets the real time clock to interrupt the program at the sample interval input during initialization. (See Real Time Clock Service Routine)

Data Collection Stop (SFK#26). Stop (3780) is the data collection stop service routine for SFK#26, STOP. The routine is bypassed if the program is not in the data collection mode. The real-time clock interrupt is disabled and the stop flag (Stp) is set. Detection of the Stop flag in Main Operating Program (See Main Operating Program) in the data collection mode causes a branch to the subroutine summary (4080). This routine dumps the graphics plot (if data plotted) onto the hard-copy printer, prints a statistical summary of the data, clears the data collection flags, and requests if the data is to be stored on magnetic tape. An affirmative response causes a branch to the subroutine create (4590) which creates a data file large enough to accommodate the number of sets of data collected and stores the data.

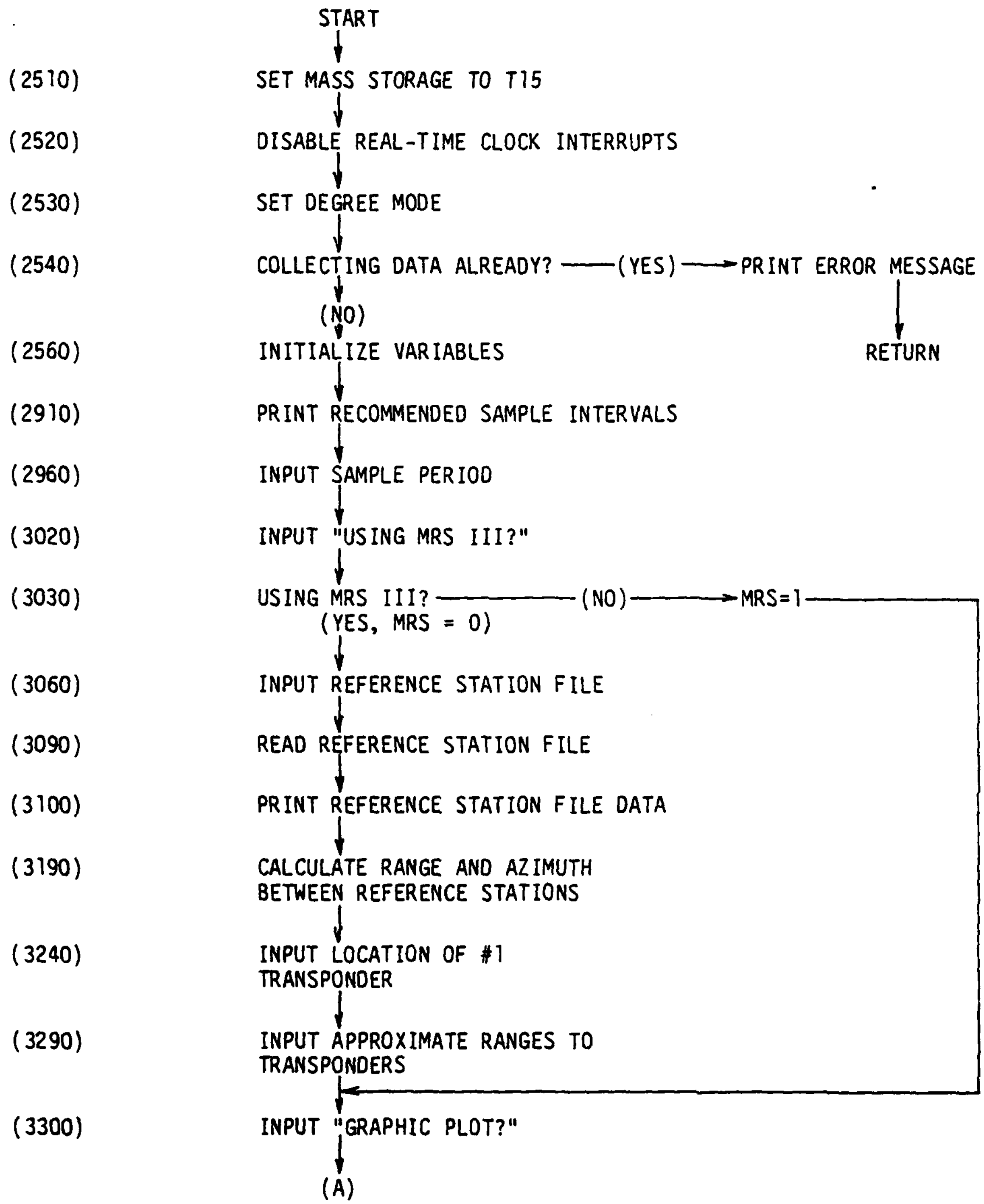


FIGURE 4-7A. FLOW CHART DATA_COL

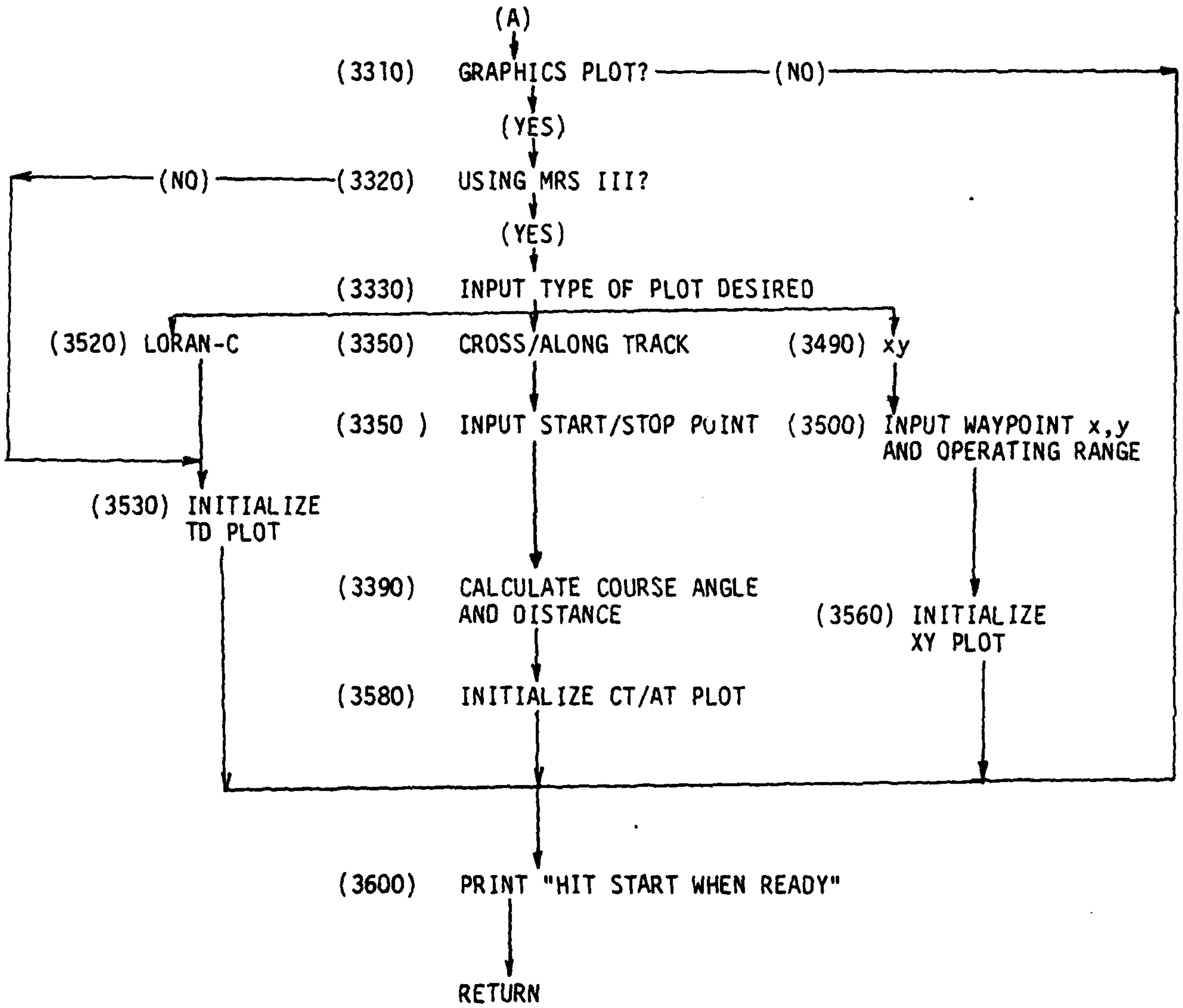


FIGURE 4-7B. FLOW CHART (cont) DATA_COL

Data Collect Pause (SFK#9). Pause (4340) is the data collect pause service routine for SFK#9, PAUSE. This routine is bypassed and an error message displayed if the program is not in the data collection mode. The routine sets the pause flag (Pause), exits graphics, and displays "YOU ARE AT A PAUSE" on the CRT. If the pause flag is detected in the main operating program (See Main Operating Program), RPRT1 messages from the AUSTRON 5000 are printed on the CRT and are not processed as data.

Data Collect Continue (SFK#10). Continue (4440) is the service routine for SFK#10, CONT. This routine is bypassed and an error message is displayed if the Pause flag is not set. The routine clears the Pause and returns graphics.

Stats (SFK#28). Stats (4560) is the service routine for SFK#28, STATS. The routine prints a summary tabulation of the statistics calculated for each TD.

Sign (SFK#29). Sign (2360) is the service routine for SFK#29, SIGN. This routine changes the sign the variable "Sign" used in position calculations (See Appendix G).

4.1.3 Real-Time Clock Interrupt

Interrupts from the real-time clock (HP98035A) are used to generate sample requests from the Mini-Ranger and AUSTRON 5000. The sample interval is set during data collect initialization and real-time clock interrupts are enabled with the data collect start command. Rtc is the real-time clock service routine. Figure 4-8 is a flow chart of Rtc. The routine executes a BEEP to indicate a sample sequence has been initiated. A timeout of 3 seconds is set for Mini-Ranger data. If the 3-second time limit is exceeded a "Timeout ERROR" message is printed and the sample is aborted. If Mini-Ranger data is being collected, the two ranges are sampled sequentially. The samples are compared to the previous sample (estimated ranges for the first sample) and if the difference is greater than 1000 meters, the sample is rejected. If the samples are within bounds, a TD sample is requested from the AUSTRON 5000 and the real-time clock interrupt is reenabled.

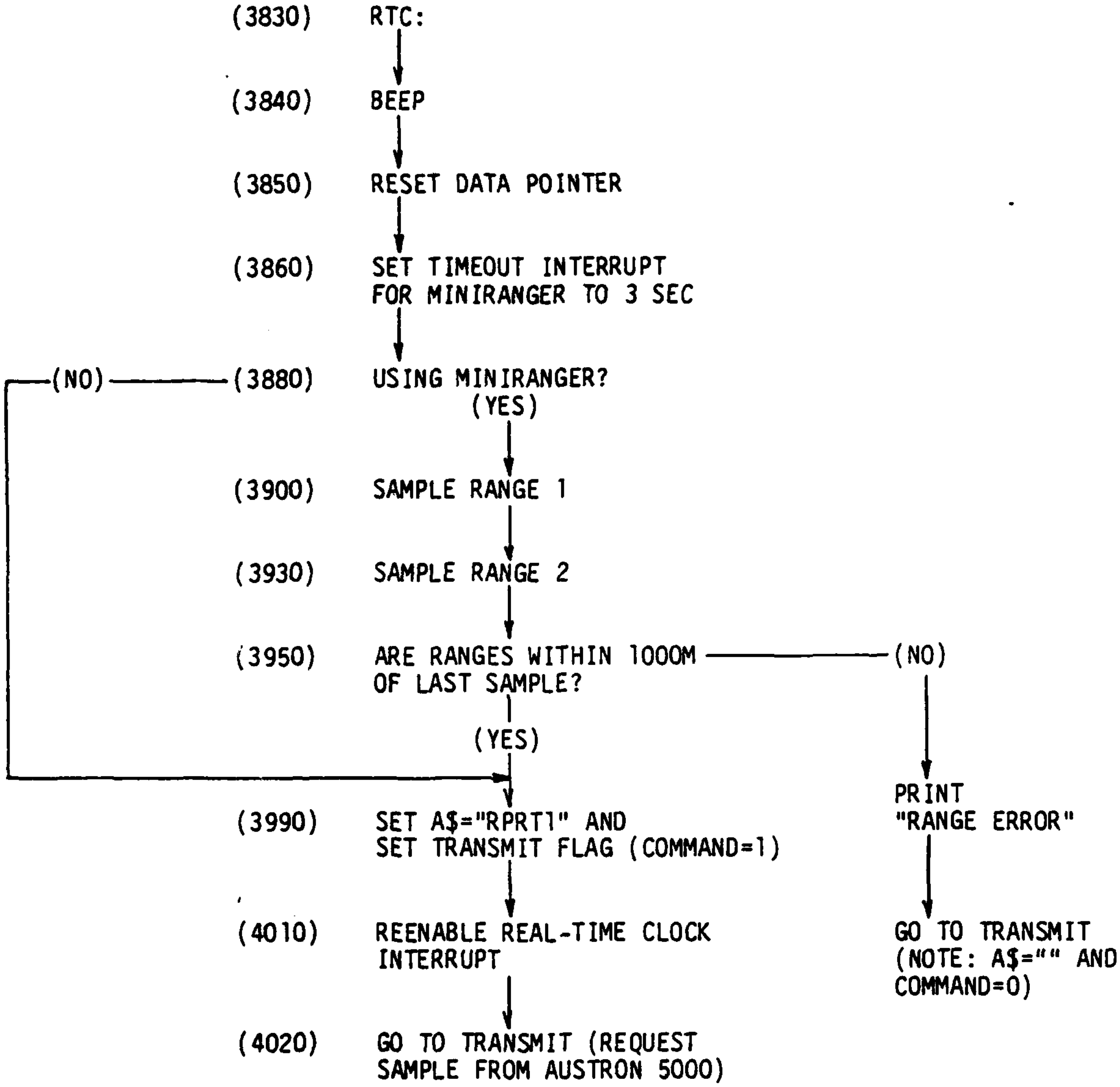


FIGURE 4-8. RTC FLOW CHART

5.0 PROGRAM OPERATING INSTRUCTIONS

5.1 Preliminary Data Collection Steps

Prior to actual data collection verify that all preliminary steps and initialization parameters have been set.

1. Enter vessel program patches (done once after reloading AUSTRON program)
2. Set time on AUSTRON 5000
3. Set Real Time Clock (optional)
4. Set AUSTRON 5000 parameters:
   TMCN 50
   CLIP 130
5. Verify all essential LORAN-C signals are locked on and tracking (one chain with (5) stations defined; master and secondaries of interest locked on).

5.2 Detailed "Survey" Program Instructions

1. Insert the survey program cartridge into the primary transport "T15" (i.e., the transport above the special function keys).

2. Load the file:

   a. Type: LOAD "SURVEY:T15"
   b. Press: EXECUTE

3. Start the program:

   a. Press: RUN

4. "RUNNING" will appear in the display area.

5. At this point, the 9845B computer is in the passive mode and any messages generated from the AUSTRON 5000 will appear on the CRT display.

   a. If the AUSTRON 5000 is initialized and locked onto all Loran signals desired, you are ready to initialize the data collection mode of operation.
   b. Insure that the AUSTRON 5000 is not setup to send back repetition RPRT's (e.g., command AUSTRON, "RPRT 1,K").

6. Data collect initialization:

   a. Hold SHIFT key down
   b. Press: SFK21 (Data_Coll)

7. When a sample period table appears in the display area:

   a. Enter: The sample period (time between samples) you desire according to the TMCN used.
   b. Press: CONT

8. When "Are you going to use MRSIII" appears in the display area:

a. If you are not going to use the MRSIII:
(1) Enter: N
(2) Press: CONT
(3) Go to Step 13
b. If you are going to use the MRSIII:
(1) Enter: Y
(2) Press: CONT

9. When "Input the reference station file name?" appears in the display area:

a. Enter: The letters for the file that sets the reference coordinates for the area under calibration.
NOTE: Files for NY are AMBROL
OUT-L
OUT-M
WARD
RARiN
b. Press: CONT

10. The reference data will be printed on the thermal line printer.

11. When "Input location of transponder #1, B or C?" appears in the display area:

a. Enter: The letter which indicates where R1 transponder is located (NOTE: Use the reference data printed out in Step 11).
b. Press: CONT

12. When "Enter approximate ranges to transponders #1 and #2, in kilometers ($\pm$0.5 km)" appears in the display area:

a. Enter: Ranges in kilometers separated by a comma (i.e., 1500, 2200).
b. Press: CONT

13. When "Do you want a graphics plot?" appears on the display:

a. If you do not want to plot data:
(1) Enter: N
(2) Press: CONT
(3) Go to Step 38
b. If you want to plot data:
(1) Enter: Y
(2) Press: CONT
(3) If using mini-ranger, go to Step 26

14. The graphics parameters will appear in the display area.

15. When "Are the graphics parameters displayed above correct?" appears in the display area:

a. Enter: Whether you want to use the graphic parameters indicated or input new ones.
   (1) If you want to use the parameters indicated:
       (a) Enter: Y
       (b) Press: CONT
       (c) Go to Step 36
   (2) If you want to enter new parameters:
       (a) Enter: N
       (b) Press: CONT

16. When "Input what you want on the X-axes?" appears in the display area:

a. Enter: The number representing the station you want to be plotted on the X-axes.
b. Press: CONT

17. When "Input what you want on the Y-axes?" appears in the display area:

a. Enter: The number representing the station you want to be plotted on the Y-axes.
b. Press: CONT

18. When "Input X-MIN?" appears in the display area:

a. Enter: The minimum value expected for the TD to be plotted on the X-axes.
b. Press: CONT

19. When "Input X-MAX?" appears in the display area:

a. Enter: The maximum value expected for the TD to be plotted on the X-axes.
b. Press: CONT

20. When "Input Y-MIN?" appears in the display area:

a. Enter: The minimum value expected for the TD to be plotted on the Y-axes.
b. Press: CONT

21. When "Input Y-MAX?" appears in the display area:

a. Enter: The maximum value expected for the TD to be plotted on the Y-axes.
b. Press: CONT

22. When "Input X-PREDICTED?" appears in the display area:

   a. Enter: The plot origin for the TD to be plotted on the X-axis (e.g., predicted waypoint).
   b. Press: CONT

23. When "Input Y-PREDICTED?" appears in the display area:

   a. Enter: The plot origin for the TD to be plotted on the Y-axis (e.g., predicted waypoint).
   b. Press: CONT

24. When "Input predicted SLOPE?" appears in the display area:

   a. Enter: The value corresponding to the predicted slope line.
   b. Press: CONT

25. At this point, you go back to Step 14 to check what was entered.

26. When "Input type of plot desired?" appears in the display area:

   a. Enter: The number 1, 2, or 3 for the type of plot you want.
   b. Press: CONT
   c. If TD plot, go to Step 14.
   d. If cross/along track plot, go to Step 27.
   e. If x,y plot, go to Step 32.

27. When "Input the co-ordinates of the starting point?" appears in the display area:

   a. Enter: The start point (km) for the trackline for along/cross track calculations.
   b. Press: CONT

28. When "Input the co-ordinates of the stopping point?" appears in the display area:

   a. Enter: The stop point (km) for the trackline for along/cross track calculations.
   b. Press: CONT

29. The start and stop points and course and range between points will be printed on the thermal line printer.

30. At this point, the CRT will be initialized with the cross-track/alongtrack graphic parameters.

31. Go to Step 38.

32. When "Input the waypoint coordinates?" appears in the display area:

a. Enter: The xy coordinates (km) for the waypoint (or point of interest).
b. Press: CONT

33. When "Input the operating range about the waypoint in kilometers?" appears in the display area:

a. Enter: The operating range about the waypoint (or point of interest) in kilometers.
b. Press: CONT

34. At this point, the CRT will be initialized with the xy graphic parameters.

35. Go to Step 38.

36. The graphic parameters will be printed on the thermal line printer.

37. At this point, the CRT will be initialized with the TD graphics parameters.

38. "Hit start when ready" will be printed on the thermal line printer.

NOTE: At this point, the vessel should be positioned at the data collection starting point.

39. When you are ready to start collecting data samples:

a. Hold SHIFT key down
b. Press: SFK 25 (STRT)

40. A beep will be heard at which point the data collection sample heading will be printed on the thermal line printer along with the start time and first data samples characteristics.

41. The graphics cursor will continue to move to the updated sample location and a beep will be heard as each sample is collected.

42. The updated samples will be printed and plotted until you stop or pause data collection.

43. At this point, the data collection program is controlled by the special function keys. Commands explained in Section 4.1.2.2.

44. Select any one of the following SFK control keys by:

a. Press: SFK 9 PAUSE Go to Step 46
SFK 10 CONTINUE Go to Step 42

b. Hold down the SHIFT key.
Press: SFK 26 STOP Go to Step 49
SFK 28 STATS Go to Step 47
SFK 29 SIGN Go to Step 48

45. The graphics display will be removed from the CRT and "you are at pause" will appear on the display. The samples will be displayed on the CRT vice being printed on the thermal line printer.

46. At this point, Austron reports are printed on the CRT and not processed. You have to go to CONTINUE mode in order to resume data collection and graphics.

a. Go to Step 43

47. The statistics based on the number of samples collected at that time will be printed out on the thermal line printer.

a. Go to Step 43

48. The value of (sign) will be shifted to the value 1 if it was -1 and vice versa. This is changed depending on which side of the baseline (B to C) the vessel is located.

a. The new value will be printed on the thermal line printer.
b. See appendix G for reference triangle calculations.
c. Go to Step 43.

49. The graphics plot will be dumped on the thermal line printer.

50. The final statistics will be printed on the thermal line printer.

51. When "Do you want to store Data Y/N?" appears in the display area:

a. If you don't want them stored on tape:
(1) Enter: N
(2) Press: CONT
(3) At this point, go to Step 4, Passive Starting Mode.

b. If you want them stored on tape:
(1) Enter: Y
(2) Press: CONT

52. When "If you have data storage tape in :T14 then -CONT" appears in the display area:

a. Insert a data cartridge into the optional transport "T14" (i.e., the transport above the typing function keys).
b. Press: CONT

53. When "Input file name?" appears in the display area:

a. Enter: Six characters representing the name of the file in which you want to store the data collected.
b. Press: CONT

54. The storage information will be printed on the thermal line printer and the data stored on magnetic tape.

a. Program returns you to Step 4, Passive Starting Mode.

APPENDIX A

AUSTRON 5000 SYSTEM COMMANDS

DEPARTMENT OF TRANSPORTATION

COAST GUARD

System Commands Handout

USCG TRACEN LOR-18 Caloc

U.S. COAST GUARD TRAINING CENTER

Governors Island, New York

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SYSTEM COMMANDS

1. The following commands are used by the control station operator and the maintenance technician in the operation of the CDFO-5000 system.

ACQ	Coarse Signal Acquisition
ADD	Add a station to a defined chain
AVG	Average Time Modifier
CAL	Acquire or Kill the Calibration chain
CD	Cycle Deviation (Envelope Number Deviation)
CLIP	Signal Sampling Clipping
CN	Cycle Nominal (Envelope Number Nominal)
CYCR	Cycle Correction Factor
DATE	Enter Day-of-Year (Julian Date)
DD	Delay Deviation (Time Delay)
DEF	Chain Defination
DN	Delay Nominal (Time Delay)
DUMP	Dump Acquisition Table
GD	Gain Deviation
GN	Gain Nominal
REL	Release a Chain or Channel
RPRT	Report of Chain Status
SMPL	Station Sample Time (Time-of-Arrival)
STOP	Stop a station tracking
STRT	Start a station tracking
TIME	Time-of-day
TMCN	PLL tracking time constant
USE	System Usage
*	Enter comments on log
#	Line erase
_	Character erase

2. The following commands are used exclusively by the control station operator:

OUT	Strip Chart Output
ZERO	Strip Chart Centering

3. The following command is used exclusively by the maintenance technician:

DSP	Front Panel Display

4. The following commands are used when the CDFO-5000 is used by more than one control station:

DENY	Deny Master Request
MSG	Message
MSTR	Request Master Control
RPMK	Report Mask Defination
WTMK	Write Mask Defination

"ACQ" - Coarse Signal Acquisition

Signal acquisition with the LORAN-C MONITOR is completely automated. A phase correlation is performed, and coarse sample times are selected from the correlation table using the data supplied in the CHAIN DEFINITION ("DEF") command. A fault message will be prepared if any of the stations do not appear in the correlation table. A front-of-pulse search determines the begining of LORAN-C energy for each station. Tracking is assumed a few cycles back in the pulse, where a zero-crossing is found and a suitable gain level is determined; standard track point search follows. Once the proper track point is found, this computation is verified. Should the verification indicate that something has gone wrong, the acquisition will be automatically re-tried once. A "WAIT" period allows for signal settling, at which time "NOMINALS" are gathered for error checking. Once all stations are in the track mode, a report will be forwarded to those control points which are to receive a report.

INPUT:

ACQ (SPACE)(CHAIN NUMBER),(OPTIONAL GAIN VALUE TO BE USED DURING COARSE ACQUISITION...default 96 db)

EXAMPLE:

ACQ 1 cr	Begin coarse acquisition on chain 1 with a gain level of 96db.
ACQ 1,50 cr	Begin coarse acquisition on chain 1 with a gain level of 50db.

CHECKS:

- Chain must be defined.
- Control point must have "WRITE" access

"ADD" - Add a Station to a Defined Chain

The "ADD" command may be used to add a LORAN-C station to a chain that has been previously defined. Only control points specified by the "WRITE" mask for the chain may alter the chain definition with the "ADD" command. After a new station has been added to a chain, its sample strobes must be positioned on the pulses with the "SMPL" command before the station tracking can be initiated with the "STRT" command.

INPUT:

ADD (SPACE)(CHAIN NUMBER)(COMMA)(STATION NAME)(COMMA)(STATION T.D.) cr

EXAMPLE:

ADD 1,W,15515 cr	Add a secondary named "WHISKEY" to chain 1 with an approximate time delay of 15515 microseconds.

CHECKS:

- The chain must be defined.
- Control point must have "WRITE" access to the chain.
- The CALIBRATION chain may not be added..it may be re-defined.
- All checks for CHAIN DEFINITION (DEF) apply.

"AVG" - Averaging Time Modifier

The averaging times for all of the LORAN-C monitor control routines (except for phase tracking, see TMCN) are based on the "AVG" numbers. The averaging time is modified by the computer based on the noise number to provide optimum performance under varying noise conditions. The averaging time modifier for each station is independent of other stations' modifiers, and as such, allows precise control over the automated, adaptive routines.

INPUT:

AVG (SPACE)(CHAIN NUMBER)(COMMA)(STATION NAME)

Read the value of the average time modifier.

AVG (SPACE)(CHAIN NUMBER)(COMMA)(STATION NAME)(COMMA)(VALUE)

Entering the value for the average time modifier.

EXAMPLES:

AVG 1,M Read the value of the time modifier for master of chain 1

AVG 1,M,2
Enter a value of 2 for master of chain 1

NOTE: AVERAGING TIME = (Rate X N) X 2^{value}
N = constant

CHECKS:

- Chain and station must be defined.
- Control point must have "WRITE" access.
- Value entered must be between -1 to 5
- *NOTE* CG-222 states the AVG value be set to 2

"CAL" - Acquire or Kill the Calibration Chain

The calibrator input may be switched inot the system at any time by the "MASTER" control point. The LORAN-C monitor will acquire the calibration chain (previously defined with the "DEF" command), and prepare a report when all stations on the chain have settled at the normal track point. Further reports may be requested at this time. Normal tracking can be resumed on command by the "MASTER" control point.

INPUT:

CAL <u>cr</u> Begin calibration mode

CAL K <u>cr</u> Terminate calibration mode

EXAMPLE:

CAL <u>cr</u>

After the calibrator signals have been acquired and the PLL's are in the track mode, the processor will print a status report.

CHECKS:

- Only the "MASTER" control point can control calibration.
- Calibration chain must be defined

"CD" - Cycle Deviation

The threshold for error monitoring of the envelope tracking is determined by an excursion beyond +/- one deviation quantum from the nominal envelope number (in cycle numbers). The envelope deviation setting for a station may be read by any control point, or may be altered or set by the "MASTER" control point. A deviation value of zero BYPASSES the "envelope out-of-tolerance" error checking.

INPUT:

CD(SPACE)(CHAIN NUMBER)(COMMA)(STATION NAME) cr

Read out the deviation setting for a station

CD (SPACE)(CHAIN NUMBER)(COMMA)(STATION NAME)(COMMA)(VALUE) cr

Assign a deviation value for a station

EXAMPLE:

CD 1,M cr	Read out cycle deviation for Master of chain 1
CD 1,M,0.5	Enter a value of 5 microseconds deviation for master of chain 1.
CD 1,M,0	Terminate cycle deviation alarm limits for Master of chain 1

CHECKS:

- Chain and channel referenced must be defined.
- If new cycle deviation number is being entered:
  - Control point must be the "MASTER" control point.
  - Value entered must be less than 50 microseconds.
- CG-222 says CD should be set to ½ assigned tolerance.

"CLIP" - Signal Sampling Clipping

Amplitude limiting of large signals is accomplished by using the "CLIP" command. Averages of the samples are gathered by the hardware (phase, amplitude, and cycle) are constantly updated. Should samples be received which are larger than the clipping level, these samples will be forced back to the respective clipping limits. The clipping operates symmetrically about the nominal value of the sample being clipped. For phase samples, this nominal value is 0, however for the cycle and amplitude samples the nominal values are approximately 112 and 128 units. The clip command is very effective in reducing servo tracking jitter caused by impulsive type noise and cross-rate signals. As a general rule, clip levels of less than 100 should not be used since this may adversely affect tracking performance of the PLL's.

INPUT:

CLIP (SPACE)(CHAIN NUMBER)(COMMA)(STATION NAME) cr

Read out clipping level for a station

CLIP (SPACE)(CHAIN NUMBER)(COMMA)(STATION NAME)(COMMA)(VALUE) cr

Enter a clipping value

EXAMPLE:

CLIP 1,M cr	Read clipping level for Master of chain 1
CLIP 1,M,130 cr	Enter clipping level of 130 units for master of chain 1

CHECKS:

- Chain and station referenced must be defined.
- If new clipping level is being entered:
  - Control point must be the "MASTER" control point.
- CG-222 says that if you use the CLIP command the value entered must not be less than 130.

"CN" - Cycle Nominal

The "nominal" cycle number for a station is initally set for each station during the "wait" period of acquisition. This nominal value may be read by any control point, or may be altered by the "MASTER" control point. The nominal, in conjunction with the deviation command (see Cycle Deviation), controls the error reports for a station.

INPUT:

CN (SPACE)(CHAIN NUMBER)(COMMA)(STATION NAME) cr

Read out nominal cycle number for a station

CN (SPACE)(CHAIN NUMBER)(COMMA)(STATION NAME)(COMMA)(VALUE) cr

Enter a cycle nominal for a station

EXAMPLE:

CN 1,M cr	Read out cycle nominal for Master of chain 1
CN 1,M,3.00 cr	Enter a cycle nominal of 3.00 for Master of chain 1

CHECKS:

- Chain and channel referenced must be defined.
- If a new cycle nominal is being entered:
    - Control point must be "MASTER" control point
    - Value entered must be less than 5 cycles

"CYCR" - Cycle Correction Factor

A correction for RF delay for each station may be entered. The number entered alters the envelope number (in cycles) for the appropriate station. The correction allows calibration of the system for measurement of ECD (Envelope-to-Cycle Difference) for each station. The cycle correction may be read by any control point.

INPUT:

CYCR (SPACE)(CHAIN NUMBER)(COMMA)(STATION NAME) cr

Read out the current value of CYCR

CYCR (SPACE)(CHAIN NUMBER)(COMMA)(STATION NAME)(COMMA)(VALUE) cr

Enter a value for CYCR

EXAMPLE:

CYCR 1,M cr	Read out current CYCR for Master of chain 1.
CYCR 1,M,0.99 cr	Enter a CYCR value of 0.99 for Master of chain 1.

CHECKS:

- Chain and channel referenced must be defined.
- If entering a new value:
  - Control point must be the "MASTER" control point.
  - Values entered must be greater than 0 but less than 1.99. Value of 1.00 = no correction.

"DATE" - Enter day of year

The "DATE" command allows entry of the day of the year. The day-of-year and time-of-day are affixed to several processor outputs. Any control point may demand the day-of-year and time-of-day by use of the "TIME" query. The day-of-year is incremented at midnight (24:00:00), and is reset to 1 after day 366. The day clock can only be manually reset by the "MASTER" control point.

INPUT:

DATE (SPACE)(DAY-OF-YEAR) cr

Enter day-of-year. (time remains unchanged)

EXAMPLE:

DATE 33 cr   Enter day-of-year for February 2.

CHECKS:

- Day-of-year must be a numeric entry, between 1 and 366.

- Control point must be the "MASTER" control point.

"DD" - Delay Deviation

The threshold for error monitoring of time difference data is determined by an excursion beyond +/- one deviation quantum from the nominal time difference (in microseconds). The time difference deviation setting for a secondary station may be read by any control point, or may be altered or set by the "MASTER" control point. A deviation value of 0 BYPASSES "time difference out-of-tolerance" error checking.

INPUT:

DD (SPACE)(CHAIN NUMBER)(COMMA)(STATION NAME) cr

Read out deviation for a station

DD (SPACE)(CHAIN NUMBER)(COMMA)(STATION NAME)(COMMA)(VALUE) cr

Enter a new deviation value for a station

EXAMPLE:

DD 1,X cr	Read out delay deviation for Xray of chain 1.
DD 1,X,0.1	Enter a delay deviation for Xray of chain 1 of 100 nanoseconds.

CHECKS:

- Chain and channel referenced must be defined.
- Station referenced must be a secondary station.
- If new values are entered:
    - Control point must be the "MASTER" control point.
    - Value entered must be less than 32 microseconds.
- CG-222 states DD to be set at 100 nanoseconds

"DEF" - Chain Definition

The define (DEF) command may be used by any control point to enter a LORAN-C chain in the system usage table. All information perteient to future use of the LORAN-C chain is entered with this command.

Once the program has determined that the input line if free of syntax errors, a "CHAIN NUMBER" is assigned (1 through 4). The operator assigns a one-letter name to each station of the chain (the MASTER is implicitly assigned "M" when you define the rate), which, along with the chain number, is used to uniquely identify each station.

There is also a space reserved for the "calibrate" chain. The "MASTER" control point must define this chain prior to any calibration checks.

Protection for the chain against unauthorized tampering by other control points is provided by specifying those control points which may "WRITE" or change data for a chain, and control points which receive reports about a chain's activity. These specifications are initialized to all control points for "report", and the control point which defined the chain for "WRITE". (The "write" mask for the calibrate chain cannot be reassigned.)

If the definition is accepted, the number assigned to the chain will be output, along with the number of chains and channels now in use.

The order in which chains are entered into the system makes no difference in the manner in which they will be tracked or in the quality of the Time Delay tracks. Their position on the oscilloscope selector switch will be in the order that they are defined.

INPUT:

DEF (SPACE)(GRP in usec)(comma)(SECONDARY #1 NAME)(COMMA)(SECONDARY NUMBER 1 APPROXIMATE TIME DELAY)(COMMA) (SECONDARY #2 NAME)(COMMA) (SECONDARY 2 APPROXIMATE TIME DELAY) etc..

DEF (SPACE)(C)(COMMA)(STA NAME)(COMMA)(STA TIME DELAY)(COMMA) (STATION NAME)(COMMA)(STA TIME DELAY)

EXAMPLE:

DEF 99600,W,15515,X,27042,Y,43851,Z,59915 cr

Enters data for loran rate 9960

DEF C,60000,A,20000,B,40000 cr

Enters data for the calibrator chain

"DEF"

CHECKS:

Non-calibration chain:

There must be an unused chain (maximum chain number = 4)

There must be an unused channel for each station in the definition. (Master occupies a channel and maximum channel usage = 8)

The GRP entered must not be that of a previously defined chain.

Calibration and non-calibration:

The GRP entered must be positive.

The GRP entered must be less than 131,072 usec.

All time delays must be positive

All time delays must be less than 131,072 usec.

All time delays must be equal to/less than 1 GRP.

Each station must be at least 10000 us from every other station on the chain.

The names entered may not be repeated on a given chain (remember the MASTER station is assigned the letter "M" when you define the Loran rate).

Calibration only:

There must not be more than 3 channels.

Calibration definition may only be done by the "MASTER" control point.

"DN" - Delay Nominal

The nominal time delay for a secondary is initiall set during the "wait" period of acquisition. This nominal value may be read by any control point, or may be altered by the "master" control point. The nominal, in conjunction with the deviation command (see Delay Deviation), controls the error reports for a station.

INPUT:

DN (SPACE)(CHAIN NUMBER)(COMMA)(STATION NAME) cr

DN (SPACE)(CHAIN NUMBER)(COMMA)(STATION NAME)(COMMA)(VALUE) cr

EXAMPLE:

DN 1,X cr	Read out the delay nominal for Xray of chain 1
DN 1,X,27042.24	Enter a nominal for Xray of chain 1 of 27042.24 usec

CHECKS:

- Chain and channel referenced must be defined.
- Station referenced must be a secondary.
- If new delay nominal is being entered:
  - Control point must be the "master" control point.

"DUMP" - Dump Acquisition Table

A table of correlation values and times of arrivals produced for every chain during acquisition. This table provides information about station signal quality and time-of-arrival. The correlation number of 64 indicates good signal quality. The correlation number has a range of 25 to 64. This table may be printed at any time following acquisition, and can be used for manual signal acquisition. Since the receiver's internal oscillator drifts slowly with time, the dump table values will eventually become invalid.

INPUT:

DUMP (SPACE)(CHAIN NUMBER) cr

EXAMPLE:

DUMP 1 cr Print chain 1's acquisition table

CHECK:

- "Chain Number" must be defined
- "Chain Number" has completed phase one of acquisition (coarse acquisition)
- Information obtained from a dump table
    - Station Identification (Master or Secondary)
    - Signal Quality
    - Times-of-Arrival (TOA)

"GD" - Gain Deviation

The threshold for error monitoring of AGC levels is determined by an excursion beyond +/- deviation quantum from the nominal gain (in dB). The gain deviation setting for a station may be read by any control point, or may be altered by the "master" control point. A deviation value of 0 bypasses error checking for AGC-level out of tolerance. Gain deviations of less than 5 should not be used since gain error messages may occur during station blink.

INPUT:

GD (SPACE)(CHAIN NUMBER)(COMMA)(STATION NAME) cr

GD (SPACE)(CHAIN NUMBER)(COMMA)(STATION NAME)(COMMA)(VALUE) cr

EXAMPLE:

GD 1,M cr	Read out gain deviation for Master of chain 1
GD 1,M,6 cr	Enter a gain deviation of 6 dB for Master of chain 1
GD 1,M,0 cr	Terminate gain deviation error checking.

CHECK:

- Chain and channel referenced must be defined
- If entering new value
    - Control point must be "master" control point
- CG-222 states GD values to be set at 6 dB

"GN" - Gain Nominal

The "nominal" gain value for a station is initially set for each station during the "wait" period of acquisition. This nominal value may be read by any control point, or may be altered by the "master" control point. The nominal, in conjunction with the deviation command (see Gain Deviation), controls the error reports for a station.

INPUT:

GN (SPACE)(CHAIN NUMBER)(COMMA)(STATION NAME) cr

GN (SPACE)(CHAIN NUMBER)(COMMA)(STATION NAME)(COMMA)(VALUE)

EXAMPLE:

GN 1,M	Read out gain nominal for master of chain 1
GN 1,M,56	Enter a gain nominal of 56 for master of chain 1

CHECK:

- Chain and channel referenced must be defined
- If new value is being entered:
    - Control point must be the "master" control point.
    - Value entered must be:
        - between 0 and 127

"REL" - Release a chain or channel

The "REL" command is used to release a chain (or channel) from the system usage table. Since this command completely eliminates the chain (or channel) from the system, one should use this command carefully. The total usage (chains and channels) of the system is output after the command has been executed.

INPUT:

REL (SPACE)(CHAIN NUMBER) <u>cr</u>

REL (SPACE)(CHAIN NUMBER)(COMMA)(STATION NAME) <u>cr</u>

EXAMPLE:

REL 1 <u>cr</u>	Release chain 1 from system usage
REL 1,X <u>cr</u>	Release station Xray from system usage. (chain 1)

CHECK:

- The chain or channel must be defined
- Control point must have "write" access to the chain
- The "calibration" chain cannot be released (it may only be redefined).

"RPRT" - Report of chain status

Report information for each chain is prepared on demand. Repetitive time-interval reports may be requested. The minimum time interval for report generation is thirty seconds. This interval may be too short if the system is reporting to several control points. It may "knot" the system up with continuous reports. Care should be taken in selecting a time interval for report generation.

The following information is included in the report for a given chain (one line per channel):

- Name of channel
- Current mode of operation
  - K = inactive station
  - A = active station
  - AF = Front-of-pulse search
  - AS = Settle (for AGC, zero-crossing lock)
  - AC = Track point search (Cycle selection)
  - AV = Verify track point
  - NOTE - up to this point if the receiver did not like the track point (2.5 or 3.5), it may go to re-try.
  - AW = Wait for final settle; pick-up "nominals"
  - AT = Normal Tracking
- Gain level
- Noise Number (see page 38)
- Cycle Number
- Sample time (TOA)
- Time delay (TD)

The signal ECD can be calculated from the cycle number:

$$ECD = 10(3.00\text{-Cycle Number})$$

The SNR (Signal-to-Noise Ratio) can be calculated from the noise number:

$$SNR = 10.5 \log_{10} (37/\text{Noise Number})$$

"RPRT"

The oscillator drift can be calculated from the difference between successive sample time readouts (use the station with the lowest noise number).

$$\text{OSC offset (parts per } 10^9) = \frac{\text{Sample time (ns)}}{\text{Time between samples (sec)}}$$

Oscillator offsets up to 50 parts per 10^9 (i.e. 50 ns/sec) are not detrimental to receiver performance since they are internally zeroed out by the receiver's PLL's. Offsets larger than this may affect acquisition performance under poor SNR conditions.

INPUT:

RPRT (SPACE)(CHAIN NUMBER) cr

RPRT (SPACE)(CHAIN NUMBER)(COMMA)(VALUE) cr

EXAMPLE:

RPRT 1 cr	Prepare report on chain 1
RPRT 1,600 cr	Prepare report on chain 1 every 600 seconds

CHECK:

- Chain referenced must be defined
- If time-interval reporting, minimum report time is 30 seconds and the maximum report time is 2047 seconds.

"SMPL" - Station sample time

Although signal acquisition and tracking are automatic, the sample time for a station may be entered manually by a control point. Extreme care should be exercised when altering a station's sample time from a remote control point; it is possible to enter a sample time that would force tracking on an undesired part of the LORAN-C pulse, or worse, attempt tracking where there is no LORAN-C pulse. If a station is added to a chain, it's sample number may be calculated by adding the TD to the master sample time. If this exceeds the GRI, then subtrack 1 GRI for the correct secondary station sample number.

INPUT:

SMPL (SPACE)(CHAIN NUMBER)(COMMA)(STATION NAME) <u>cr</u>

SMPL (SPACE)(CHAIN NUMBER)(COMMA)(STATION NAME)(COMMA)(VALUE) <u>cr</u>

EXAMPLE:

SMPL 1,M — Read Master sample time (chain 1)

SMPL 1,M,9876 — Enter Master sample time of 9876 usec. (chain 1)

CHECK:

- Chain and channel referenced must be defined.
- If a new value is being entered:
    - Control point must be the "master" control point
    - Value of the input must be positive and less than 1 GRI

"STOP" - Stop a station tracking

The status (tracking/stopped) may be controlled manually. Once a station is stopped, the "STRT" command may be used to re-acquire the station.

INPUT:

STOP (SPACE)(CHAIN NUMBER)(COMMA)(STATION NAME) <u>cr</u>

EXAMPLE:

STOP 1,X   Stops station Xray from tracking

CHECK:

- Chain and channel referenced must be defined
- Control point must have "write" access

"STRT" - Start a station tracking

Acquisition for a station may be initiated with the "STRT" command. The acquisition begins at the sample time entered by the "SMPL" command (or, the last sample time for the station). Front-of-pulse search, zero-crossing lock, and standard track point determination proceed as with the chain acquisition routine. (see ACQ)

INPUT:

STRT (SPACE)(CHAIN NUMBER)(COMMA)(STATION NAME) <u>cr</u>

EXAMPLE:

STRT 1,X <u>cr</u>   Start station Xray of chain 1 tracking.

CHECK:

- Chain and channel referenced must be defined
- Control point must have "write" access

"TIME" - Time-of-Day

The time-of-day, along with the day-of-year, is used to preface reports and error messages. The clock is maintained in the software by using the one second interrupt generated by the RCVR. The clock should thus be reset after any processor restart (either manual restart or power fail auto-restart).

The clock is maineained as a 24 hour clock, reading to 23 hours, 59 minutes, 59 seconds - then resetting to 00:00:00 at midnight (at which the day-of-year is incremented).

NOTE: The day clock can only be manually reset by the "master" control point.

INPUT:

TIME cr

TIME (SPACE)(HOURS)(:)(MINUTES)(:)(SECONDS) cr

EXAMPLE:

TIME cr	Read day-of-year and time-of-day from the system clock.
TIME 01:09:44 cr	Set the clock to 01 hours, 09 minutes, and 44 seconds (day-of-year remained unchanged).

CHECK:

- Hours must be a positive number, less than 24
- Minutes and seconds must be a positive number, less than 60
- Control point must be the "master" control point

"TMCN" - PLL Time constant

The time constant for the software low-pass filter incorporated in the phase-tracking algorithm may be entered or examined with the "TMCN" command. The operator enters values in units of GRI's. Values of 100, 200, 400, 800, or 1600 GRI's may be selected.

INPUT:

TMCN (SPACE)(CHAIN NUMBER)(COMMA)(STATION NAME) cr

TMCN (SPACE)(CHAIN NUMBER)(COMMA)(STATION NAME)(COMMA)(VALUE) cr

EXAMPLE:

TMCN 1,M cr	Read PLL time constant for Master of chain 1
TMCN 1,M,200 cr	Enter PLL time constant of 200 for Master of chain 1

CHECK:

- Chain and channel referenced must be defined
- If value is being entered:
    - Control point must have "write" access to the chain
    - Values of the input must be one of the following; 100, 200, 400, 800, 1600
- To determine the servo loop time constant in seconds

SERVO LOOP TC = TMCN VALUE * RATE (in seconds)

"USE" - System Usage

Before defining a chain or adding a station (channel) to a chain definition, the operator may check to see if there is room in the system for the stations to be added. The "USE" command allows the operator to query the system for both the number of chains and the number of tracking channels in use. (System capacity is four chains; eight channels)

INPUT:

USE cr

EXAMPLE:

USE cr — The processor would respond with:

SYSTEM USAGE: 1 CHAIN 3 CHANNELS

CHECK:

None

"*" - Enter Comments

It is often desirable to comment on the hardcopy log produced at a control point. Since the teletype communciation is full-duplex, a special character (*) must be entered to the system to allow echoing of the data. All data entered after this command is ignored by the system until a carriage return is typed.

INPUT:

* (COMMENTS) <u>cr</u>

EXAMPLE:

* Adjusted oscillator

CHECK:

None

"#" - Line Erase

An entire line of a command may be erased with the "#" (shift 3) command. This can be used to cancel a command before it is entered with a carriage return.

INPUT:

#

EXAMPLE:

ACQ 1#	Cancel acquisition of chain 1

CHECK:

None

"_" - Character Erase

If a typing mistake is made during entry of a command, the last character can be erased with the "_" (shift "O") command. When this editing command is used repeatedly, successive characters are erased until the begining of the line is reached.

INPUT:

_

EXAMPLE:

TMCN 1,_ _2,M cr   Corrects chain 1 to chain 2

CHECK:

None

"OUT" - Strip Chart Output

A coded block of TTY data containing strip chart update information is transmitted by the computer every 10 seconds. This information is translated at the control station by the CDFO-6019 Information Switch into analog voltages to drive up to 8 strip chart recorders. The strip chart updat blocks are prevented from reaching the control station teleprinter by the Information Switch.

INPUT:

OUT (SPACE)(CHAIN NUMBER)(COMMA)(STATION NAME)(COMMA)(DATA)(COMMA)(CHART RECORDER NUMBER) cr

DATA

C = Cycle number

D = Time delay (secondaries only)

K = stops all updates from the processor

EXAMPLE:

OUT 1,M,C,1 cr	Output Chain 1, Master station, Cycle information on chart recorder number 1.
OUT K cr	Stops all updates from the processor

CHECK:

- Control point must have "write" access
- Chain and channel must be defined

"ZERO" - Strip Chart Centering

The strip chart outputs set up with the "out" commands and can be adjusted with the "ZERO" command.to center the recorder pens for the desired TD's or Cycle Numbers. The value of the "ZERO" command is calculated by taking the fractional part of the DATA (TD or CN) and adding 0.5. The result is the ZERO command for centering the chart.

INPUT:

ZERO (SPACE)(CHART RECORDER NUMBER)(COMMA)(OFFSET VALUE) <u>cr</u>

EXAMPLE:

ZERO 1 <u>cr</u>	Read the current value of offset for chart recorder number 1.
ZERO 1,.83	Centers chart recorder number 1 for an offset of .83 (i.e. Say X TD is on recorder number 1 with a TD number of 27354.33 usec; .33 + .5 = .83)
ZERO 2,.39	Centers chart recorder number 3 for an offset of .39 (i.e. Say M CN is on recorder number 3 with a CN of 2.89 cycles; .89 + .5 = 1.39 use .39)

CHECK:

- Recorder channel must be any number 1 through 8

"DSP" - Front Panel Display

Complete control is provided over the data displayed on the two front panel NIXIE displays, D1 and D2.

INPUT:

DSP (SPACE)(UorL)(COMMA)(CHAIN NUMBER)(COMMA)(STATION NAME)(COMMA)(DATA) cr

DSP (SPACE)(UorL)(COMMA)(T) cr

EXAMPLE:

DSP U,T cr	Display time in the upper display
DSP L,1,M,C	Display chain 1, Master station, Cycle information in the lower display.

CHECK:

- Control point altering NIXIE displays must be the "master" control point.
- Chain and channel referenced must be defined
- Station referenced must be a secondary station for Time Delay
- Information that can be displayed in the NIXIE Display:

  C = Cycle numbers

  S = Sample time (TOA)

  T = Time-of-day

  D = Time Delay (TD)

"DENY" - Deny Master Request

Once a master request has been initiate there is a 60 second clock in the processor that begins counting. If the current master control point does not "DENY" the master request, master control will be passed to the control point initiating the request. The new control point will have control over the calibration chain, nominal values, and deviations.

INPUT:

DENY cr

EXAMPLE:

001 00:01:23 MASTER REQUEST B cr

The above is control point B asking for master control.

DENY cr — You have just denied control point B master control if you entered "DENY" before the 60 second clock completed counting.

CHECK:

None

"MSG" - Message

Messages may be relayed between control points. Since the eight-bit ASCII code is used in the software, any ASCII character may be used in the message (except the special characters: "carriage return", "#","_"). It may be especially useful to use the ASCII "bell" character (control G) to alert the receiver to special messages. A single message may be routed to one or many control points, including a special routing from the sender to himself.

INPUT:

MSG (SPACE)(RECEIVING CONTROL POINTS)(COMMA)(MESSAGE CONTENT) <u>cr</u>

EXAMPLE:

MSG ABC, ARE YOU RECEIVING BAD DATA FROM THIS SITE? <u>cr</u>

The above you are asking control points A, B, and C if the lormonsite is feeding them bad information.

CHECK:

- All names in the list must be proper control point names (i.e. A, B, C, D, E, or F)
- There must be at least one control point name in the list.

"MSTR" - Request Master Control

The LORAN-C monitor has a "master" control point, which is the only control point that can perform special tasks such as: setting "TIME", setting "DATE", controlling the calibration chain, entering nominal values, and entering deviation values for alarm generation.

Control point "A" is initially the "master" control point. The "master" status may be requested by any control point, and if no other control point denies that request, the master status is passed from the previous "master" to the requesting master.

INPUT:

MSTR cr	Request "master" control point status.

CHECK:

None

"RPMK" - Report Mask Definition

The destination for reports prepared for each LORAN-C chain may be specified with the "RPMK" command. This command defines a "mask" of control points to which the reports are sent. The "report mask" can only be altered by control points with "write" access to a chain. The "report mask" is initialized to all control points when a chain is defined.

INPUT:

RPMK (SPACE)(CHAIN NUMBER)(COMMA)(LIST OF CONTROL POINTS) cr

EXAMPLE:

RPMK 1,ABC	Forwards all future reports to control points A, B, an C only.

CHECK:

- Control point must have "write" access to the chain

- All names in the list must be proper control point names (i.e. A, B, C, D, E, or F).

- There must be at least one valid control point in the list

"WTMK" - Write Mask Definition

In order to minimize erroneous data entry and alleviate unauthorized tampering with control of a chain, a list of control points which may alter data for a chain is maintained in the software. All attempts by a control point to enter or alter data for a chain causes a check to be made to determine whether the control point may "write" data for this chain.

INPUT:

WTMK (SPACE)(CHAIN NUMBER)(COMMA)(LIST OF CONTROL POINTS) cr

EXAMPLE:

WTMK 1,A cr	Only control point A can change any data pertaining to chain 1

CHECK:

- Control point attempting to exercise command must have "write" access.
- All names in the list must be proper control point names (i.e. A, B, C, D, E, or F).
- At least one control point in the list must be in the system to avoid assigning capabilities to a non-existent control point.

AUSTRON 5000 RECEIVER

NOISE NUMBER - SNR RELATIONSHIP (FOR GAUSSIAN NOISE)

NOISE #	SNR	NOISE #	SNR	NOISE #	SNR
1	16.47	25	1.79	49	-1.28
2	13.31	26	1.61	50	-1.37
3	11.46	27	1.44	55	-1.81
4	10.14	28	1.27	60	-2.20
5	9.13	29	1.11	65	-2.57
6	8.30	30	0.96	70	-2.91
7	7.59	31	0.81	75	-3.22
8	6.98	32	0.66	80	-3.52
9	6.45	33	0.52	85	-3.79
10	5.97	34	0.39	90	-4.05
11	5.53	35	0.25	95	-4.30
12	5.13	36	0.12	100	-4.53
13	4.77	37	0.00	110	-4.97
14	4.43	38	-0.12	120	-5.37
15	4.12	39	-0.24	130	-5.73
16	3.82	40	-0.36	140	-6.07
17	3.55	41	-0.47	150	-6.38
18	3.29	42	-0.58	160	-6.68
19	3.04	43	-0.69	170	-6.95
20	2.81	44	-0.79	180	-7.21
21	2.58	45	-0.89	190	-7.46
22	2.37	46	-0.99	200	-7.69
23	2.17	47	-1.09	250	-8.71
24	1.97	48	-1.19	300	-9.54

APPENDIX B

AUSTRON 5000 FAULT COMMANDS

DEPARTMENT OF TRANSPORTATION

COAST GUARD

FAULT COMMANDS HANDOUT

CALCC LOR-18

U.S. COAST GUARD
TRAINING CENTER

Governors Island, New York

ET50/G
10/29/80

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ACQ FAULT

The receiver acquisition process begins by examining the GRI specified or Loran-C signals. The result of this search is a correlation table which may be examined by the user with the "DUMP" command. If no Loran-C energy (coherent RF) has been found in the loran repetition interval for the station specified, the ACQ FAULT message is printed.

EXAMPLE: 001 01:21:03 1,W ACQ FAULT

PROBABLE CAUSE:

- Signal off air or SNR less than -15 dB.
- Incorrectly specified time delay for a secondary station. Delete the station with the proper time delay.
- If all stations, or just the Master Station, the problem may be incorrectly specified loran rate. Delete the chain and redefine with the proper rate and time delays.
- Receiver in CAL mode after system calibration. Type CAL K cr
- Loss of signals to the receiver.
- Insufficient warmup time for the receiver's internal temperature stabilized crystal oscillator. Allow at least 10 minutes warm-up after receiver turn-on before attempting to acquire signals.

AD-A115 588 COAST GUARD RESEARCH AND DEVELOPMENT CENTER GROTON CT F/G 17/7
TIME DIFFERENCE SURVEY SYSTEM (TDSS).(U)
APR 81 A J SEDLOCK, T J MILNE, J P LEWICKI
UNCLASSIFIED CGR/DC-16/81 USCG-D-72-81 NL

2 of 2
AD
A115588

END
DATE
FILMED
7 82
DTIC

BLINK BGN/BLINK END

The blink code is used by the Loran-C system to warn the user that a problem exists in one or more chain baselines and these stations should not by used for navigation purposes. The blink indication is detected by the receiver when:

- The Master Station 9th pulse is turned off and on with the blink code for the baseline affected.
- A secondary Station turns off and on the first two pulses in the standard secondary blink code.

The receiver uses averaging to prevent false blink indications under noisy conditions. The averaging is adaptive to compensate for increasing noise. The blink message will generally be printed within a few seconds after the initiation of the blink condition at the transmitting station under good SNT conditions. The time for blink detection in the receiver will increase as the SNR decreases.

EXAMPLE: 001 10:02:10 1,X,BLINK BGN

PROBABLE CAUSE:

- Designated station is transmitting blink code.
- Continuous Master blink on and off messages during Master blink area due to insufficient averaging. This can be corrected by increasing AVG for the Master Station.
- Excessive link blink detection times may be decreased by decreasing AVG for that station. This problem usually occurs for stations with poor SNR.

BUSY

During initial phase of signal acquisition, the receiver is doing continuous signal sampling and transferring the data to the processor. Insufficient processor time is available for normal teleprinter I/O so the BUSY message is transmitted.

EXAMPLE:

- Enter the following:

  ACQ 1 <u>cr</u>

  ACQ 2 <u>cr</u>

  BUSY The processor response.

PROBABLE CAUSE:

- Signal acquistion has been requested within the last 20 seconds.

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CODE ERROR BGN/CODE ERROR END

The amplitude samples for each station are algebraically averaged together for each station. This average will reach unique steady state values for the Master station and the Secondary stations. If this average exceeds some preset limits, a CODE ERROR message will be printed. Generally, more than one pulse in a GRI must be in error before the alarm is given.

EXAMPLE:

001	10:00:11	1,Y,CODE ERROR BGN
001	10:04:11	1,Y,CODE ERROR END

PROBABLE CAUSE:

- High noise or loss of signal may temporarily set off the alarm. Such false alarms would be accompanied by abnormally large noise numbers.

- Error in transmitted phase code. If more that one monitor receiver prints this message, the offending station should investigate a phase code problem by observing the antenna current signals.

CYCLE ERROR BGN/CYCLE ERROR END

Presetable tolerance limits can be placed on the Cycle number calculation. When the calculated cycle number exceeds either the upper or lower tolerance limit, the error message is given.

EXAMPLE:

```
001     10:11:00     1,X,CYCLE ERROR BGN

001     10:11:50     1,X,CYCLE ERROR END
```

PROBABLE CAUSE:

- Transmitter off-air causing the cycle number to drive to 5.00. This should correct itself once the station returns on-air.
- The transmitted ECD has changed or changes in the propagation path have caused the ECD of a station measured at the monitor site to exceed the tolerance limit.
- Incorrectly set CN or CD command.
- Incorrectly set CYCR

ERROR

Syntax errors in data typed on the teleprinter are noted by the ERROR command. Generally, this is due to a missing character or comma. If it is not clear what error was made, the command dictionary should be checked to verify the proper format is being used. The carot indicates the approximate position of the error.

EXAMPLE:

```
ADD 1,52000 cr
ERROR A
```

PROBABLE CAUSE:

- Error made on teleprinter entry.
- Distortion on TTY lines or TTY "hits" on transmit line.

ET50/G
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GAIN ERROR BGN/GAIN ERROR END

A tolerance window can be placed on the reciever AGC for each station. If the gain increases or decreases to the tolerance limit the GAIN ERROR BGN message will be printed and the gain will be clamped at this limit.

EXAMPLE:

100	00:09:55	1,Y,GAIN ERROR BGN
100	00:11:59	1,Y,GAIN ERROR END

PROBABLE CAUSE:

- Station off air
- Incorrectly set GN or GD command
- Secondary station blinking with GD command set at 4 dB or less.

HIGH NOISE BGN/HIGN NOISE END

If the noise number calculated by the receiver exceeds 4095, then the NOISE BGN error message is printed. The HIGH NOISE END message is printed when the calculated noise number falls back below 3072. The noise number is a measure of all interference, both natural and man-made.

EXAMPLE:

099	11:11:11	1,M,HIGH NOISE BGN
099	11:59:00	1,M,HIGH NOISE END

PROBABLE CAUSE:

- Station off-air and no gain deviation limits set in. The AGC drives to the maximum limit under these conditions and the background noise sampled by the receiver is thus very large.
- Very large increase in natural or man-made noise. This would be confirmed by an increase in noise numbers on all stations with no change in station gains.

HYPRB ERROR BGN/HYPRB ERROR END

Tolerance limits for the measured time difference can be preset into the computer. When a tolerance level is exceeded, the error message is printed. The station PLL continues to track beyond this limit.

EXAMPLE:

100	11:59:00	1,X,HYPRB ERROR BGN
100	12:11:59	1,X,HYPRB ERROR END

PROBABLE CAUSE:

- Secondary station jumped time if a message is printed for one baseline.
- Master station jumped time if a message is printed for all baselines.
- DD or DN improperly set.

PROTECTED

The CDFO-5000 Monitor Set can be configured to operate on several chains with several user terminals. To prevent confusion and inadvertent modification of another users parameters, a protocol system can be set-up which protects each user's parameters. This message is printed when an unauthorized user tries to modify parameters in a chain.

EXAMPLE:

CN 1,M,2.95 cr
PROTECTED

(User 2 attempts to change chain 1 cycle nominal for master)

PROBABLE CAUSE:

- User terminal does not have "write" access. Check the chain designation in the command to verify that an authorized chain number has been used.

- See the WTMK and MSTR commands in the Command Dictionary to change the "write" authorization.

SKYWAVE ERROR BGN/SKYWAVE ERROR END

A "guard strobe" is used to sample signals -37.5 usec in front of the signal tracking point. Under normal conditions there is no coherent RF at the guard strobe point. If the reciever is tracking high on the pulse, then this alarm will be printed. Man-made communications signals which are coherent with the Loran-C signal can cause this same indication. Occurrences of this type of interference are rare.

EXAMPLE:

111	11:00:11	1,X,SKYWAVE ERROR BGN
111	11:11:11	1,X,SKYWAVE ERROR END

PROBABLE CAUSE:

- Receiver tracking too high on the pulse. Check the cycle number and CYCR to determine if this is the cause.

- Synchronous or near-synchronous RFI contaminating the signal.

- Temporary large noise burst. To verify, check noise numbers for abnormally high value.

RETRY BGN/RETRY FAIL

If the receiver fails to find a satisfactory sample point in the "AC" mode during signal acquisition, it will return to the front-of-pulse search and print a RETRY BEGIN message. If the acquisition fails the second time, the station is placed in the "K" (killed) mode.

EXAMPLE:

222	22:23:00	1,Z,RETRY BGN
222	22:23:59	1,Z,RETRY FAIL

PROBABLE CAUSE:

- Envelope correction factor "CYCR" set so that the measured cycle numbers are near the indecision points of 2.5 and 3.5. Change the CYCR to correct this condition.

APPENDIX C

TOPAZ MODIFICATIONS

TOPAZ ISOLATION TRANSFORMER MODIFICATION

The following is a brief description of the modification made to the TOPAZ ultra-isolation transformer:

1. Identification Of Modification:

   a. 4" x 4" x 3" electrical connection box with unground receptacle mounted on output end of TOPAZ.

2. Material Required For Each Modification:

a.	Electrical box, 4" x 4" x 2-1/8" (or deeper)	1 each
b.	2-pole, 3-wiring ground receptacle, 20A, 125V	1 each
c.	Cover, electrical box, single outlet, 4" x 4" x 1/2"	1 each
d.	Cap, motor run, 4mf/375V	1 each
e.	Pipe nipple, 3/4" x 1-1/2"	1 each
f.	Locknut, 3/4"	1 each
g.	Bushing, 3/4"	1 each
h.	#12 AWG copper wire, 1 BLK, 1 WHT, 1 GRN	18" each
i.	Terminal lugs	8 each
j.	Conduit clamp, 1-1/2"	1 each
k.	1/4" x 20" x 3/4" machine screw and nut and lock washer	2 each
l.	#8-32 machine screws, 1"	2 each

3. Procedure:

   a. Remove cover from output end of TOPAZ.
   b. Remove lower (larger) knock-out from end bell on right-hand side as you face transformer from output end.
   c. Note which 3/4" knock-out on electrical box most nearly lines up with TOPAZ knock-out. Remove it and enlarge it with 1" Greenlee punch.
   d. Fasten the electrical box to the TOPAZ end bell using the pipe nipple, lock nuts, and bushing.
   e. Using 1/4" bit and hard drill, drill through the electrical box and end bell of TOPAZ as shown in accompanying drawing. Hold the clamp and capacitor in place to mark location of hole. NOTE that cap must be mounted in upright position and clamp must engage lip of capacitor can to prevent possibility of electric connections on capacitor making contact with electrical box due to vibrations during shipment and use.
   f. Solder a 6" piece of black #12 wire to the terminal on the capacitor marked with the dot, and a 6" piece of white #12 to the other. Mount the capacitor as shown and install terminal lugs on the free ends. Connect these wires to the top pair of connections on the receptacle (black to brass terminal, white to silver terminal).
   g. Install terminal lugs on both ends of a black, white, and green 10" to 12" piece of #12 AWG wire. Connect the black from X1-X3 on the TOPAZ to the brass connection on the receptacle. Connect the white from X2-X4 of the TOPAZ to the silver connection on the receptacle. Connect the green from the chassis connection of the TOPAZ to the

ground connection on the receptacle. (If X1 is not jumpered to X3 and X2 is not jumpered to X4, do so now.)

h. Mount receptacle to cover, cover to box, replace end bell.

i. Open input end of TOPAZ and make sure H1 is jumpered to H3 and that H2 is jumpered to H4. If not, do so now.

j. Modification is complete.

All material procured locally.

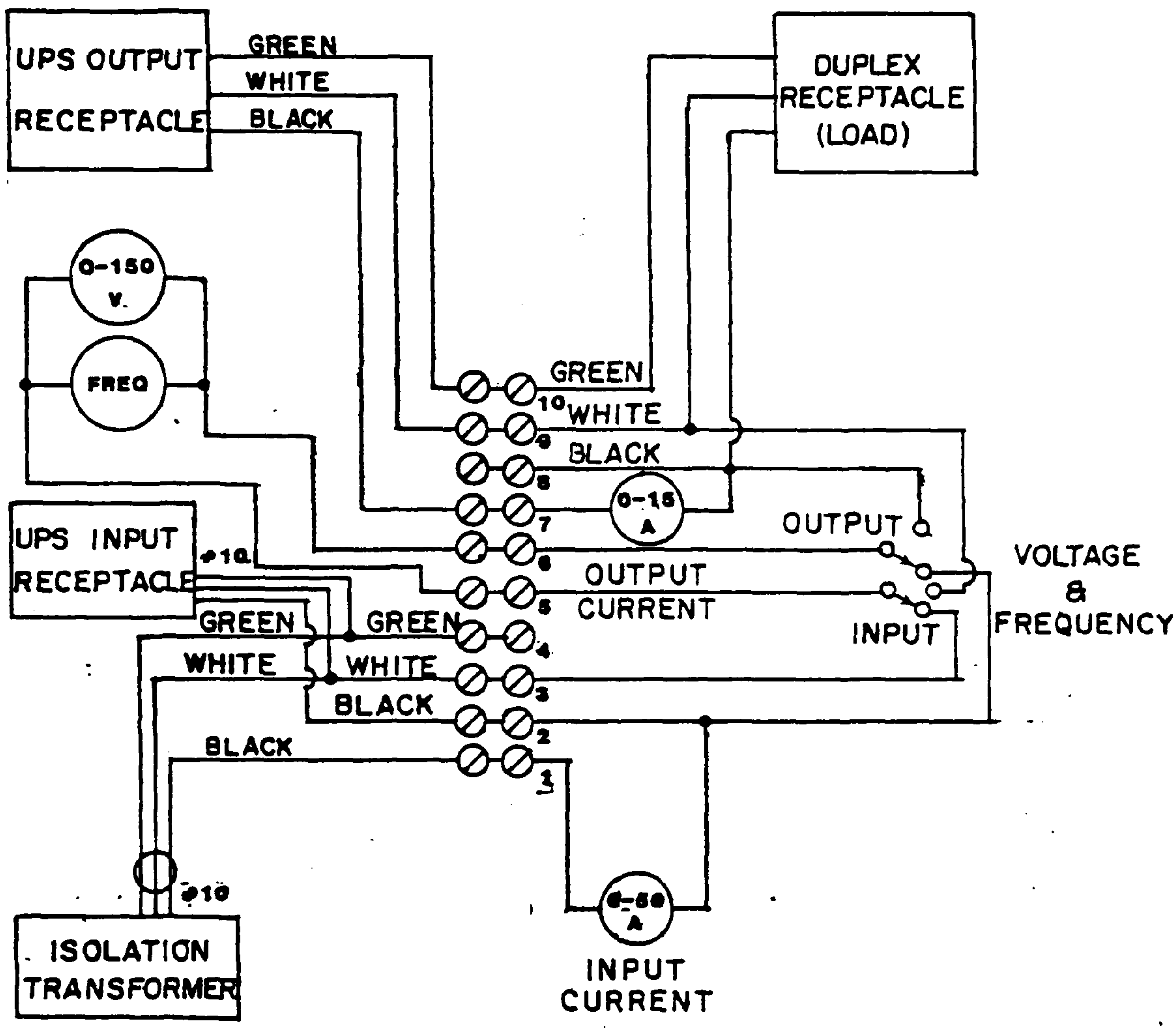


FIGURE C-2 UPS MONITOR PANEL FIELD CHANGE

APPENDIX D

"SURVEY" PROGRAM LISTING

```
10   !                       "SURVEY"
20   ! ORIGINAL (R&D 05/01/81)                    "DOCUMENTATION TAPE"
30   ! *******************************************************
40   ! *  AUSTRON 5000 DATA COLLECTION PROGRAM USING UPDATED    *
50   ! *  REPORTS CONTROLLED BY H/P 9845B.                     *
60   ! *  PROGRAM COMMENCED 1/22/79                            *
70   ! *  LAST MODIFICATION 04/09/81 by ETCS Thomas J. Milne   *
80   ! *  ORIGINAL PROGRAM DEVELOPED BY:                       *
90   ! *       LCDR ANDREW J. SEDLOCK  (G-DST-1)               *
100  ! *       CWO2 JAMES P. LEWICKI   (USCG R&D CTR)          *
110  ! *       ETCS THOMAS J. MILNE    (USCG R&D CTR)          *
120  ! *  THIS PROGRAM DESIGNED FOR 9600 BAUD,WITH REPORTS      *
130  ! *  UPDATED AS FAST AS EVERY (12) SECONDS                *
140  ! *  EFFECTIVE 1 MAY 1981, THIS IS THE ONLY VERSION OF    *
150  ! *  SOFTWARE IN USE WITH THE (TDSS) SURVEY,AND MAY NOT   *
160  ! *  BE MODIFIED IN ANY WAY WITHOUT THE SPECIFIC WRITTEN  *
170  ! *  PERMISSION OF THE USCG RESEARCH AND DEVELOPMENT      *
180  ! *  CENTER.                                              *
190  ! *******************************************************
200  OPTION BASE 1
210  MASS STORAGE IS ":T15"
220  COM Buf$[159],Cursor,Dcom$[500],Sel_code,Kbd,Data,Data_collect,Sample,Set,S
fk
230  DIM A$[200],B$[500],C$[100],A1(100),A2(100),A3(100),A4(100),B1(100)
240  DIM B2(100),B3(100),B4(100),C1(100),C2(100),C3(100),C4(100),Td(6)
250  DIM D1(100),D2(100),D3(100),D4(100),Std_dev(4),Slop(4),Stats(4,4),Cov(3,5)
260  DIM T1$(100),T2$(100),T3$(100),T4$(100),Sums(3,4),Stat(3,4),Reg(4,4),O_set(
6)
270  DIM S(4,6),R(3,6),At$(16),Z(2),Zo(2),Bug$(33)
280  DIM E1(100),E2(100),E3(100),E4(100),F1(100),F2(100),F3(100),F4(100)
290  DIM Ref(10,2),Ref$(10)
300  INTEGER Sample_period
310  Bug_com=0
320  Bug_count=1
330  IF Sfk=1 THEN 350
340  LOAD KEY "SFK"
350  Sfk=1
360  GOSUB Keys
370  Cursor=1
380  Sel_code=10         !  RS232C(EIA) select code
390  Data_collect=0      !  flag indicating data collection has been started
400  Data=0              !  data_coll key check flag
410  Dp=0                !  complete message (report) check flag
420  Set=1               !  increments the 100 sample set counter
430  Sample=0            !  sample counter
440  Stp=0               !  stop flag
450  Pause=0             !  pause flag
460  Mrs=0               !  mini-ranger use flag
470  CALL Dcom_setup(Err)              !SETUP RS 232C
480  IF Err THEN Dcom_err              !I/O ERROR SO STOP
490  TOPEN Sel_code,15 CALL Dcom_isr! OPEN COMMS CHANNEL WITH AUSTRON
500  CONTROL MASK 9;128 !  initializes the real time clock for interrupts
510  OUTPUT 9;"A,U2=02"
520  DISP "RUNNING"
530 Loop:!
540   IF Bug_com=1 THEN CALL Debug(A$,Bug$(*),Bug_com,Bug_count)
550   IF Bug_com=0 THEN 580     ! patches end flag
560   Bug_count=Bug_count+1     ! counts commands sent to AUSTRON
570   Comand=1                  ! sets transmit command flag
580   IF NOT Kbd AND FNKbd_ready THEN Off_kbd
590 Receive:!
600       IF NOT FNDc_ready THEN Transmit! Check for CR or SOH in DCOM$
610       CALL Get_data(B$,Prompt)        ! Get message and message type
620       ON Prompt GOTO Msg,Receive,Receive ! If prompt=1 then the data is a tel
e-
630                                ! type message;2,strip chart message;
```

```
640                                     ! 3,incomplete strip chart message
650 Msg:                                   !
660       IF NOT Data_collect THEN Print ! If not in DATA COLLECT mode then
670                                     ! print message
680       IF B$="RPRT1" THEN 610
690                                     ! samples, then print msg
700       IF (Dp=0) AND (Pause=1) THEN Ptcrt! If in PAUSE mode print msg on crt
710       IF B$[17;5]="CHAIN" THEN Data  ! Check for first line of RPRT msg
720       IF Dp>0 THEN Data              ! Process data sample
730       GOTO Print
740 Transmit:      !
750       IF FNKbd_ready AND Kbd THEN Xmit1 ! Check for STORE,CONT,EXECUTE or SFK
4 in
760                                 ! teletype mode
770       IF NOT Comand THEN 870        ! Check for Austron command in
780       Comand=0                      ! calculator mode
790       GOTO Xmit
800 Xmit1:  CALL Get_line(A$)           ! Get msg from keyboard buffer
810     Cursor=1
820 Xmit:FOR I=1 TO LEN(A$)             ! Transmit message to Austron
830       OUTPUT Sel_code USING "#,K";A$[I,I]
840       WAIT 60
850       NEXT I
860       OUTPUT Sel_code USING "#,K";CHR$(13)
870       IF NOT (Stp AND (Dp=0)) THEN Loop
880       GOSUB Summary
890 Ptcrt:!
900       PRINTER IS 16
910 Print: !
920    IF Bug_com=1 THEN PRINTER IS 0
930       PRINT B$
940       B$=""
950       IF FNDc_ready THEN 610
960       GOTO Transmit
970 Data: !                        STRIP DATA FROM REPORT MESSAGE
980       Dp=Dp+1                       ! Increment data pointer
990       IF Dp=1 THEN Time             ! If first line of msg get time
1000      IF Dp=2 THEN Master           ! If second line of msg check master track
1010      Td(Dp-2)=VAL(B$[32])          ! Strip off the TD from msg line
1020      B$=""
1030      IF Dp<6 THEN 610              ! Have you received all (5) msg lines
1040      Dp=0                          ! If yes reset msg pointer then process data
1050      GOTO Process
1060 Master:!
1070      IF B$[5,5]<>"T" THEN Error1      ! Check if master is in track
1080      B$=""
1090      GOTO 610
1100 Error1:!
1110      BEEP
1120      DISP "MASTER NOT IN TRACK !!!!!!!!"
1130      Dp=0
1140      GOTO Receive
1150 Time:!
1160      Time$=B$[3,14]                  ! Strip time off first line of msg
1170      B$=""
1180      GOTO 610
1190 Process:!
1200 Store:                    ! This routine stores TD's in data arrays
1210      Sample=Sample+1     ! This increments the sample counter
1220      IF Data_collect=1 THEN PRINTER IS 0
1230      IF Sample>1 THEN 1300
1240      PRINT LIN(1);"____________________________________________________________
_________________"
1250      PRINT LIN(2);TAB(1),"SAMPLE";TAB(11),"W";TAB(21),"X";TAB(31),"Y";TAB(41
),"Z";TAB(51);"Set";TAB(56);"R1";TAB(63);"R2";TAB(70);"Time"
1260      IF Mrs=1 THEN 1280
```

```
1270     PRINT LIN(1);TAB(12),"( A";TAB(20),"B";TAB(25),"C )=";TAB(31),"(A+B+C)"
;TAB(45);"X /";TAB(50);"Y";TAB(64);"AT /";TAB(70);"CT"
1280     PRINT LIN(2);TAB(53);"Start Time";TAB(64);Time$
1290     PRINT LIN(1)
1300     IF Sample<400 THEN 1320
1310     GOSUB Stop
1320  STANDARD
1330     PRINT Sample;
1340     FIXED 2
1350     PRINT TAB(10);Td(1);TAB(20);Td(2);TAB(30);Td(3);TAB(40);Td(4);
1360     STANDARD
1370     IF Sample/(Set*100)>1 THEN Set=Set+1 ! Increments set counter every
1380     PRINT TAB(51);Set;R1;R2;Time$[4;9]
1390 ON Set GOTO One,Two,Three,Four          ! hundred samples
1400 One:A1(Sample)=Td(1)
1410     B1(Sample)=Td(2)
1420     C1(Sample)=Td(3)
1430     D1(Sample)=Td(4)
1440     E1(Sample)=R1
1450     F1(Sample)=R2
1460     T1$(Sample)=Time$
1470     GOTO Position
1480 Two:A2(Sample-100)=Td(1)
1490     B2(Sample-100)=Td(2)
1500     C2(Sample-100)=Td(3)
1510     D2(Sample-100)=Td(4)
1520     E2(Sample-100)=R1
1530     F2(Sample-100)=R2
1540     T2$(Sample-100)=Time$
1550     GOTO Position
1560 Three:A3(Sample-200)=Td(1)
1570       B3(Sample-200)=Td(2)
1580       C3(Sample-200)=Td(3)
1590       D3(Sample-200)=Td(4)
1600       E3(Sample-200)=R1
1610       F3(Sample-200)=R2
1620       T3$(Sample-200)=Time$
1630       GOTO Position
1640 Four:A4(Sample-300)=Td(1)
1650      B4(Sample-300)=Td(2)
1660      C4(Sample-300)=Td(3)
1670      D4(Sample-300)=Td(4)
1680      E4(Sample-300)=R1
1690      F4(Sample-300)=R2
1700      T4$(Sample-300)=Time$
1710 Position:!                        CALCULATE POSITION FROM MRS DATA
1720  IF Mrs=1 THEN 1890! TD only skip position calculations
1730         FIXED 1
1740         Ra=R*1000
1750         Rb=R2
1760         Rc=R1
1770         IF NOT Tp THEN Rb=R1
1780         IF NOT Tp THEN Rc=R2
1790       CALL Triangle(Ra,Rb,Rc,A,B,C)
1800        CALL Position(Zo(*),Alpha,Rc/1000,Sign,B,Z(*))
1810        IF Pt$<>"Y" THEN 1870
1820        IF Plott<>2 THEN 1870
1830        X=Z(1)-X1
1840        Y=Z(2)-Y1
1850        At=X*SIN(Course)+Y*COS(Course)
1860        Ct=X*COS(Course)-Y*SIN(Course)
1870    Td(1)=Z(1)
1880    Td(4)=Z(2)
1890 Stat: CALL St(Td(*),Sample,Stats(*),Cov(*),O_set(*))!Calculate statistics
1900 Regress: CALL Reg(Stats(*),Cov(*),S(*),R(*),O_set(*))!calculate regression
1910  IF Mrs=1 THEN 1940                                  !coefficient
```

```
1920  FIXED 3
1930  PRINT TAB(2);"(";A;B;C;")";"=";A+B+C;SPA(2);Z(1);"/";Z(2);SPA(2);At;"/":Ct
,LIN(1)
1940  IF Stp THEN Data_collect=0
1950  IF Pause THEN Transmit
1960  IF Pt$<>"Y" THEN Transmit    ! Check if plot is desired
1970                                ! Plot data
1980  IF Mrs=1 THEN 2000
1990  ON Plott GOTO 2000,2040,2020
2000  CALL Disp_run(Td(*),Sample,Xmn,Xmx,Ymn,Ymx,Mp,Xaxes,Yaxes,Prx,Pry,Cba,Lcb,
Cbb,Cbc,Lcb2,Lcb3,Stp,R(*))
2010  GOTO 2050
2020 CALL Plot_xy(Sample,Wp_x,Wp_y,Z(*),Op_r)
2030  GOTO 2050
2040   CALL Plot_ct(Ct,At,Rdist,Sample)
2050  GOTO Transmit
2060 Keys:!                           SETS UP THE SFK'S
2070     ON KEY #18 GOSUB Acq1
2080     ON KEY #19 GOSUB Rprt1
2090     ON KEY #20 GOSUB Tmcn
2100     ON KEY #8 GOSUB On_kbd
2110     ON KEY #9 GOSUB Pause
2120     ON KEY #10 GOSUB Continue
2130     ON KEY #21 GOSUB Data_coll
2140     ON KEY #25 GOSUB Start
2150     ON KEY #26 GOSUB Stop
2160     ON KEY #28 GOSUB Stats
2170     ON KEY #29 GOSUB Sign
2180     ON KEY #27 GOSUB Debug
2190   RETURN
2200 Acq1: !
2210   IF Data_collect THEN RETURN
2220   A$="ACQ1"
2230   Comand=1
2240   RETURN
2250   !
2260 Rprt1:!
2270   IF Data_collect THEN RETURN
2280   A$="RPRT1"
2290   Comand=1
2300   RETURN
2310 Tmcn:!
2320   INPUT "INPUT THE TMCN YOU DESIRE ?",Tm
2330   A$="TMCN1,M,"&VAL$(Tm)&CHR$(141)&"TMCN1,W,"&VAL$(Tm)&CHR$(141)&"TMCN1,X,"
&VAL$(Tm)&CHR$(141)&"TMCN1,Y,"&VAL$(Tm)&CHR$(141)&"TMCN1,Z,"&VAL$(Tm)
2340   Comand=1
2350   RETURN
2360 Sign:!
2370   Sign=-1*Sign
2380   PRINT "SIGN=";Sign
2390   RETURN
2400 On_kbd:                  ! SETS KEYBOARD IN TELETYPE MODE
2410   ON KBD CALL Kbd_isr ! ON KBD setsup an interrupt condition,and activates
2420   DISP "TELETYPE ON"  ! a character buffer(KBD$) which stores data from
2430   RETURN              ! the keys pressed.
2440 Off_kbd:!                         RETURN KEYBOARD TO CALCULATOR MODE
2450  Cursor=1
2460     OFF KBD
2470     A$=""
2480     DISP "TELETYPE OFF"
2490   GOTO Loop
2500 Data_coll:!                      INITIALIZE DATA COLLECTION
2510  MASS STORAGE IS ":T15"
2520  OFF INT #9
2530    DEG
2540    IF Data_collect THEN Imc        ! Improper command if already in
```

```
2550                                            ! data collect mode
2560    Sign=1
2570    Data=1
2580    Sample=0
2590    Set=1
2600    Mrs=0
2610    R1=0
2620    R2=0
2630    RESTORE 2650
2640    READ Range_1,Range_2
2650    DATA 114,116
2660    MAT A1=ZER                              ! Zero data arrays
2670    MAT B1=ZER
2680    MAT C1=ZER
2690    MAT D1=ZER
2700    MAT E1=ZER
2710    MAT F1=ZER
2720    MAT A2=ZER
2730    MAT B2=ZER
2740    MAT C2=ZER
2750    MAT D2=ZER
2760    MAT E2=ZER
2770    MAT F2=ZER
2780    MAT A3=ZER
2790    MAT B3=ZER
2800    MAT C3=ZER
2810    MAT D3=ZER
2820    MAT E3=ZER
2830    MAT F3=ZER
2840    MAT A4=ZER
2850    MAT B4=ZER
2860    MAT C4=ZER
2870    MAT D4=ZER
2880    MAT E4=ZER
2890    MAT F4=ZER
2900    PRINTER IS 16
2910    PRINT "Recommended sample periods :"
2920    PRINT TAB(5);"Sample period=(TMCN*2)/10 "
2930    PRINT TAB(5);"Mininimum sample period=12sec"
2940    PRINT TAB(6);"TMCN";TAB(27);"Sample period"
2950    PRINT LIN(1);TAB(6);"25 minimum";TAB(27);"12",TAB(6);"50";TAB(27);"12",T
AB(6);"100";TAB(27);"20"
2960    INPUT "Input the sample period(sec) you desire ?,then CONT",Sample_per
iod
2970    IF Sample_period<12 THEN Sample_period=12
2980    STANDARD
2990    PRINTER IS 0
3000    PRINT "The sample period=one sample every";Sample_period;"Sec"
3010    P$=VAL$(1000*Sample_period)  !This sets the clock time in millisec
3020    INPUT "Are you going to use MRSIII ?, Y=YES,N=NO",Mrs$
3030    IF Mrs$<>"Y" THEN Mrs=1
3040  IF Mrs THEN 3300
3050  PRINTER IS 0
3060      INPUT "Input the reference station file name?",Rf$
3070      PRINT "REFERENCE STATION FILE =:";Rf$
3080      ASSIGN #1 TO Rf$
3090      READ #1;Ref$(*),Ref(*)
3100      PRINT "REFERENCE STATIONS:"
3110      PRINT TAB(5);"B";TAB(8);Ref$(1);TAB(30);Ref(1,1);TAB(55);Ref(1,2)
3120      PRINT TAB(5);"C";TAB(8);Ref$(2);TAB(30);Ref(2,1);TAB(55);Ref(2,2)
3130      PRINT "LOCAL GRID ORIGON:"
3140      PRINT TAB(8);Ref$(3);TAB(30);Ref(3,1);TAB(55);Ref(3,2)
3150      Zo(1)=Ref(1,1)-Ref(3,1)
3160      Zo(2)=Ref(1,2)-Ref(3,2)
3170      Zc(1)=Ref(2,1)-Ref(3,1)
3180      Zc(2)=Ref(2,2)-Ref(3,2)
```

```
3190     R=SQR((Zc(1)-Zo(1))^2+(Zc(2)-Zo(2))^2)
3200     Alpha=ATN((Zc(1)-Zo(1))/(Zc(2)-Zo(2)))
3210     IF Zc(2)-Zo(2)<0 THEN Alpha=Alpha+180
3220     IF Alpha<0 THEN Alpha=Alpha+360
3230     PRINT "RANGE BETWEEN STATIONS=";R,"ANGLE=";Alpha
3240     INPUT "Input location of transponder #1, B OR C ?",Tp$
3250     IF (Tp$="B") OR (Tp$="C") THEN 3270
3260     GOTO 3240
3270     IF Tp$="B" THEN Tp=1
3280     IF Tp$="C" THEN Tp=0
3290     INPUT "Enter approximate ranges to transponders #1 & #2,in Kilometers(+
-.5KM)",Rf1,Rf2
3300    INPUT "Do you want a graphics plot ?,Y=Yes,N=No",Pt$
3310 IF Pt$<>"Y" THEN 3600
3320  IF Mrs THEN 3520 ! INITIALIZE TD GRAPHICS
3330  INPUT "Input type of plot desired,TD=1,CROSS/ALONG TRACK=2,OR XY=3 ?
",Plott
3340  ON Plott GOTO 3520,3350,3490
3350        INPUT "Input the co-ordinates of the starting point,Kilometers East,N
orth ?= X,Y",X1,Y1
3360        INPUT "input the co-ordinates of the stopping point,Kilometers East,N
orth ?= X,Y",X2,Y2
3370        Dy=Y2-Y1
3380        Dx=X2-X1
3390       Rdist=SQR(Dy^2+Dx^2)
3400        Course=ATN(Dx/Dy)
3410        IF Dy<0 THEN Course=Course+180
3420        IF Course<0 THEN Course=Course+360
3430        FIXED 1
3440        PRINT "FROM POINT 1 TO POINT 2, COURSE=";Course;", RANGE=";Rdist
3450        PRINT "STARTING POINT";X1,Y1
3460        PRINT "END POINT";X2,Y2
3470        GOTO 3580! INITIALIZE CT/AT GRAPH
3480    STANDARD
3490    INPUT "Input the waypoint coordinates, Kilometers East,North ?= X,Y",Wp_
x,Wp_y
3500    INPUT "Input the operating range about the waypoint in Kilometers ?",Op_
r
3510    GOTO 3560! INITIALIZE XY PLOT
3520    CALL Graf(Xmn,Xmx,Ymn,Ymx,Mp,Xaxes,Yaxes,Prx,Pry) ! Initialize graphics
3530   CALL Disp_run(Td(*),Sample,Xmn,Xmx,Ymn,Ymx,Mp,Xaxes,Yaxes,Prx,Pry,Cba,Lcb
,Cbb,Cbc,Lcb2,Lcb3,Stp,R(*))
3540   GOTO 3600
3550   IF Ct$="Y" THEN 3580
3560 CALL Plot_xy(Sample,Wp_x,Wp_y,Z(*),Op_r)
3570  GOTO 3600
3580  CALL Plot_ct(Ct,At,Rdist,Sample)
3590   PRINTER IS 0
3600    PRINT "HIT STRT WHEN READY"
3610    RETURN
3620 Imc:  DISP "IMPROPER COMMAND(Imc)!"
3630    RETURN
3640 Start:!                                START COMMAND
3650    IF NOT Data THEN Ic
3660    IF Data_collect THEN Ic
3670      ON INT #9 GOTO Rtc
3680    CONTROL MASK 9;128
3690    CARD ENABLE 9
3700    OUTPUT 9;"U2H,U2P"&P$&"/U2G"
3710    Data_collect=1
3720    PRINTER IS 16
3730    PRINT PAGE
3740    PRINTER IS 0
3750    RETURN
3760 Ic:  DISP "IMPROPER COMMAND(Ic)!"
3770    RETURN
```

```
3780 Stop:!                                             STOP COMMAND
3790     IF NOT Data_collect THEN Ic
3800       OFF INT #9
3810     Stp=1
3820     RETURN
3830 Rtc: !
3840 BEEP
3850  Dp=0
3860  SET TIMEOUT 4;3000
3870   ON INT #4 GOTO Timeout
3880  IF Mrs=1 THEN 3990
3890   WRITE BIN 2;0
3900   WRITE BIN 2;Range_1
3910  ENTER 4;R1,C1
3920  WRITE BIN 2;0
3930   WRITE BIN 2;Range_2
3940  ENTER 4;R2,C2
3950  IF ABS(R1-Rf1*1000)>1000 THEN Range_error
3960  IF ABS(R2-Rf2*1000)>1000 THEN Range_error
3970  Rf1=R1/1000
3980  Rf2=R2/1000
3990  A$="RPRT1"
4000  Comand=1
4010  CARD ENABLE 9
4020  GOTO Transmit
4030 Timeout:  PRINT "Timeout ERROR"
4040  GOTO 4010
4050 Range_error:  PRINT "RANGE ERROR"
4060  GOTO 4010
4070  !
4080 Summary:!
4090     PRINTER IS 0
4100     PRINT TAB(51);"Stop time";TAB(62);Time$
4110    IF Pt$<>"Y" THEN 4150
4120     PRINT LIN(5)
4130     DUMP GRAPHICS
4140     EXIT GRAPHICS
4150     CALL Pstats(Stats(*),O_set(*),Cov(*),R(*),Sample)
4160     Data=0
4170     Kill=0
4180     Stp=0
4190     Data_collect=0
4200     Plot=0
4210     Pause=0
4220     INPUT "DO YOU WANT TO STORE DATA ON TAPE? Y OR N",Files
4230     IF Files="Y" THEN 4260
4240     DISP "RUNNING"
4250     RETURN
4260     DISP "IF YOU HAVE DATA STORAGE TAPE IN :T14 THEN - CONT "
4270     PAUSE
4280     GOSUB Create
4290     DISP "RUNNING"
4300     RETURN
4310 Dcom_err:  !
4320    DISP "I/O ERROR,OVERLOAD, HIT CONT "
4330    STOP
4340 Pause:!  Pauses data collection
4350     IF NOT Data_collect THEN Err
4360     Pause=1
4370     EXIT GRAPHICS
4380     PRINTER IS 16
4390     PRINT "YOU ARE AT A PAUSE"
4400     RETURN
4410 Err:     !
4420     DISP "IMPROPER COMMAND!!!!!!"
4430     RETURN
```

```
4440 Continue:! Starts the data collection again
4450      IF NOT Pause THEN Er
4460      Pause=0
4470      IF Plot=0 THEN Clear
4480      GRAPHICS
4490      RETURN
4500 Clear:PRINTER IS 16
4510      PRINT PAGE
4520      RETURN
4530 Er: !
4540      DISP "IMPROPER COMMAND!!!!"
4550      RETURN
4560 Stats:    !
4570      CALL Pstats(Stats(*),O_set(*),Cov(*),R(*),Sample)
4580      RETURN
4590 Create:    !
4600 MASS STORAGE IS ":T14"
4610 INPUT "Input file name ?",Fname$
4620  STANDARD
4630 PRINT "Set=";Set
4640 PRINT "FILE NAME=";Fname$
4650 PRINT "SAMPLES= ";Sample
4660 CREATE Fname$,Set,7000       !300 BYTES / ARRAY + 1200 BYTES / STRING
4670 ASSIGN #1 TO Fname$        !One data set = 4400 BYTES= 44 BYTES PER SAMPLE
4680 PRINT #1;Set
4690 PRINT #1;Sample
4700 ON END #1 GOTO 4720
4710  PRINT #1;A1(*),B1(*),C1(*),D1(*),E1(*),F1(*),T1$(*)
4720  PRINT "Set 1 stored"
4730  IF Set=1 THEN 4840
4740  ON END #1 GOTO 4760
4750  PRINT #1;A2(*),B2(*),C2(*),D2(*),E2(*),F2(*),T2$(*)
4760  PRINT "Set 2 stored"
4770  IF Set=2 THEN 4840
4780  ON END #1 GOTO 4800
4790  PRINT #1;A3(*),B3(*),C3(*),D3(*),E3(*),F3(*),T3$(*)
4800  PRINT "Set 3 stored"
4810  IF Set=3 THEN 4840
4820  ON END #1 GOTO 4840
4830  PRINT #1;A4(*),B4(*),C4(*),D4(*),E4(*),F4(*),T4$(*)
4840  PRINT "Storage done"
4850  MASS STORAGE IS ":T15"
4860  RETURN
4870 Debug: ! MODIFY AUSTRON PROGRAM FOR AIRCRAFT OR VESSEL USE.
4880  INPUT "Do you want to insert the AUSTRON program patch Y/N ?",Debug$
4890  IF Debug$<>"Y" THEN 4950
4900  RESTORE 4920
4910  READ Bugs$(*)
4920  DATA DEBUG,OP10346,RE7700,OP15570,RE4700,OP15571,RE6340,OP15572,RE7160,OP1
5573,RE7470,OP15574,RE7634,OP15575,RE7716,OP15576,RE7747,OP15615,RE1377
4930  DATA OP15617,RE1376,OP15631,RE1375,OP15640,RE1374,OP15774,RE5570,OP15775,R
E0007,OP15776,RE5567,OP15777,RE7771,OP10146,RE7773,OP16642,RE0012,DONE
4940  Bug_com=1
4950  RETURN
4960  END
4970 ! ***************************************************************
4980 SUB Kbd_isr      !          KEYBOARD SERVICE SUBROUTINE
4990 Kbd_isr: COM Kbd$[159],Cursor,Dcom$[500],Sel_code,Kbd
5000    DIM K$[20]
5010    Kbd=1
5020    ON ERROR GOTO Keyofl  !Run_time error occuring when program is running
5030    K$=KBD$        !Store keys pressed in K$
5040    OFF ERROR        !Disables ON ERROR statement.
5050 Nextkey: IF NOT LEN(K$) THEN Goway
5060         IF NOT Cursor THEN Beep
5070         K=NUM(K$)
```

```
5080            IF K=255 THEN Second  !Implies special function key hit
5090            K$=K$[2]       !Key stroke = second key hit
5100            IF (Cursor=160) OR (K=12) THEN Beep
5110            IF K=8 THEN Lf
5120            Kbd$[Cursor;1]=CHR$(K)
5130 Ri:        IF LEN(Kbd$)<Cursor THEN Nextkey
5140                TDISP Kbd$[Cursor;1]
5150            Cursor=Cursor+1
5160            GOTO Nextkey
5170 Keyofl:    DISP "Keyboard buffer overflow."
5180            BEEP
5190 Goway:     SUBEXIT    !Returns to calling program before SUBEND is reached.
5200 Second:    IF LEN(K$)>1 THEN Sfk
5210              K$=K$&KBD$
5220            GOTO Second
5230 Sfk:       K=NUM(K$[2])
5240            K$=K$[3]
5250            Shift=K DIV 64
5260                K=BINAND(K,63)
5270            ON ERROR GOSUB Nada
5280            ON K+1 GOTO U0,U1,U2,U3,U4,U5,U6,U7,U8,U9,Ua,Ub,Uc,Ud,Ue,Uf
5290            ON K-15 GOTO Step,Pa,Ru,Co,St,Ex,Lf,Ri,Up,Dn,Rlu,Rld,Ho,Clr,C2e
5300            ON K-30 GOTO Dlc,Inc,Dll,Inl,Rcl,Tab,Tbs,Tbc,Typ
5310            ON K-49 GOTO Bs,Res,Stop,Cll
5320            OFF ERROR
5330 Beep:      BEEP
5340            GOTO Nextkey
5350 Nada:      RETURN
5360 Pa:          WRITE IO Sel_code,5;1
5370              WRITE IO Sel_code,4;46
5380              WRITE IO Sel_code,5;132
5390            BEEP
5400            WAIT 200
5410            BEEP
5420              WRITE IO Sel_code,5;1
5430              WRITE IO Sel_code,4;7
5440              WRITE IO Sel_code,5;132
5450            GOTO Nextkey
5460 Bs:        !
5470 Lf:        IF Cursor<2 THEN Nextkey
5480            Cursor=Cursor-1
5490                TDISP CHR$(8)
5500            GOTO Nextkey
5510 Clr:      ! PRINT PAGE;
5520            DISP
5530 Cll:       Kbd$=""
5540 Ho:        Cursor=1
5550            GOTO Pall
5560 C2e:       Kbd$[Cursor]=""
5570 Pall:          TDISP CHR$(12)&Kbd$&RPT$(CHR$(8),LEN(Kbd$)-Cursor+1)
5580            GOTO Nextkey
5590 Co:!
5600 St:!
5610 Ex:        IF (K<19) OR (K>21) THEN Beep
5620            Cursor=0
5630            SUBEXIT
5640 U4:        Kbd=0                 ! RETURN KEYBOARD TO CALCULATOR MODE
5650            Cursor=0
5660        SUBEND            !Returns to calling program.
5670        SUB Get_line(Line$)
5680 Get_line:COM Kbd$[159],Cursor,Dcom$[500],Sel_code
5690 Loop:      IF NOT FNKbd_ready THEN Loop
5700            Line$=Kbd$
5710                TDISP CHR$(12)    !Clears the entry keyboard line
5720            Kbd$=""
5730            Cursor=1
```

```
5740      SUBEND
5750      SUB Dcom_isr!      COMMUNICATIONS SUBROUTINE
5760 Dcom_isr:COM Kbd$[159],Cursor,Dcom$[500],Sel_code
5770           DIM D$[330]
5780               D$=TBUF$           !This stores data coming in from 98036A
5790                                !into D$ from TBUF$
5800          ! IF LEN(D$)+LEN(Dcom$)>500 THEN Error
5810           IF LEN(D$)+LEN(Dcom$)>500 THEN Dcom$=""
5820           Dcom$[LEN(Dcom$)+1]=D$       !Add on to the internal buffer
5830           SUBEXIT
5840 Error:  DISP "Datacomm overrun."
5850  Ovr=LEN(Dcom$)+LEN(D$)
5860  DISP "Overun= ";Ovr
5870  Dcom$=D$
5880           BEEP
5890      SUBEND
5900  SUB Dcom_setup(Err) !    SETUP RS 232
5910 Dcom_set:COM Kbd$[159],Cursor,Dcom$[500],Sel_code
5920             READ Stopbits,Parity,Bitsperchar,Bitratefactor
5930             DATA 1,2,3,2      !At 9600 baud/ bit rate factor is 1/16
5940             Err=0
5950             IF NOT IOSTATUS(Sel_code) THEN Error !If RS-232 is 0 / not
5960                                                  ! operational then an error
5970                                                  ! occurs.
5980             STATUS Sel_code;S                    ! S is the status of the
5990                                                  ! RS-232,0 to 511,S=402
6000               IF BINAND(S,48)<>16 THEN Error      ! BINAND(402,48)=16
6010             WRITE IO Sel_code,5;1                ! Set control mode
6020             WRITE IO Sel_code,4;64               ! Reset USART
6030             WRITE IO Sel_code,4;Stopbits*64+Parity*16+(Bitsperchar-5)*4+Bitr
atefactor                                             ! Set mode word
6040             WRITE IO Sel_code,4;39               ! Set control word
6050             WRITE IO Sel_code,5;0                ! Set data mode
6060             READ IO Sel_code,4;S                 ! Read,register(4)=S=133
6070             WRITE IO Sel_code,7;0
6080             WRITE IO Sel_code,5;132
6090             STATUS Sel_code;S                    ! S=402
6100               IF BINAND(S,128) THEN SUBEXIT        ! BINAND(402,128)=128
6110                                                  ! Bit 7 interrupt enable or
6120                                                  ! Bit 8 Peripheral Status
6130                                                  ! has to be enabled
6140 Error:   DISP "Select code not operational."
6150           BEEP
6160           Err=1    ! IF Err=1 upon exiting subprogram,then communications
6170                    ! link was not established.
6180 SUBEND
6190 DEF FNDc_ready  !  CHECK FOR CR OR SOH CHARACTER IN Dcom$
6200 Dc_rdy:            COM Kbd$[159],Cursor,Dcom$[500],Sel_code
6210   RETURN POS(Dcom$,CHR$(141)) OR POS(Dcom$,CHR$(129))  !If there is neither
 then
6220 ! RETURN POS(Dcom$,CHR$(13)) OR POS(Dcom$,CHR$(1))  !If there is neither th
en
6230                                                      ! a 0 is the returned
6240 FNEND
6250 DEF FNKbd_ready  !  CHECK FOR CR (EXECUTE,CONT,OR SF4)
6260 Kbd_rdy: COM Kbd$[159],Cursor,Dcom$[500],Sel_code
6270 RETURN NOT Cursor  ! Returns a 0 if Cursor is 1
6280                          ! Returns a 1 if CONT,EXECUTE,STORE
6290                          ! was hit
6300 FNEND
6310 SUB Get_data(A$,Prompt) ! Get data from Dcom$,data in circular buffer TBUF$
6320 Get_data:COM Kbd$[159],Cursor,Dcom$[500],Sel_code
6330    Prompt=1
6340    DIM Z$[500]
6350    IF NOT FNDc_ready THEN 6350
6360    N1=POS(Dcom$,CHR$(141))     !Position of CR in data
```

```
6370  ! N1=POS(Dcom$,CHR$(13))      !Position of CR in data
6380    N2=POS(Dcom$,CHR$(129))       !Position of SOH in data
6390   ! N2=POS(Dcom$,CHR$(1))       !Position of SOH in data
6400    IF N2>0 THEN Data            !If SOH is in the data then take out strip
6410                                 ! chart data
6420    A$=Dcom$[1,N1-1]        ! If no SOH data is everything up to the CR
6430    Dcom$=Dcom$[N1+1]       ! The rest of the data is put into Dcom$
6440    IF A$[1,1]=CHR$(138) THEN A$=A$[2] !If the first character is a LF take
6450 !  IF A$[1,1]=CHR$(10) THEN A$=A$[2] !If the first character is a LF take
6460                                           ! everything after the LF
6470    FOR I=1 TO LEN(A$)
6480    Z$[I,I]=CHR$(NUM(A$[I,I])-128)
6490    NEXT I
6500    A$=Z$
6510    SUBEXIT
6520 Data:    IF LEN(Dcom$)-N2<9 THEN Depart !If the data is less than 9
6530                                           ! characters then the data is no goo
d
6540    Prompt=2                             !goto loop
6550    A$=Dcom$[N2,N2+9]    !Stripchart date is taken out and put in A$
6560    Dcom$=Dcom$[1,N2-1]&Dcom$[N2+10] !Remaining data is combined
6570    SUBEXIT
6580 Depart:    Prompt=3
6590 SUBEND
6600 SUB Disp_run(O(*),N,Xmn,Xmx,Ymn,Ymx,Mp,Xaxes,Yaxes,Prx,Pry,Cba,Lcb,Cbb,Cbc,
Lcb2,Lcb3,Stp,Sdev(*))
6610    DIM Yd(1),Xd(1),Xplot(1),Yplot(1),X$[3],Y$[3],Cb(1),P$[20]
6620    IF N<=0 THEN 6660
6630    Dev_w=Sdev(2,1)/SQR(N)*1000
6640    Dev_x=Sdev(2,4)/SQR(N)*1000
6650    Dev_y=Sdev(2,6)/SQR(N)*1000
6660    ON Xaxes GOTO 6670,6700,6730,6760
6670    X$="TDW"
6680    Xplot=O(1)
6690    GOTO 6780
6700    X$="TDX"
6710    Xplot=O(2)
6720    GOTO 6780
6730    X$="TDY"
6740    Xplot=O(3)
6750    GOTO 6780
6760    X$="TDZ"
6770    Xplot=O(4)
6780    ON Yaxes GOTO 6790,6820,6850,6880
6790    Y$="TDW"
6800    Yplot=O(1)
6810    GOTO 6900
6820    Y$="TDX"
6830    Yplot=O(2)
6840    GOTO 6900
6850    Y$="TDY"
6860    Yplot=O(3)
6870    GOTO 6900
6880    Y$="TDZ"
6890    Yplot=O(4)
6900    Xd=Xmx-Xmn
6910    Yd=Ymx-Ymn
6920    Cb=Dev_w*(Yd/50)
6930    Cb2=Dev_x*(Yd/50)
6940    Cb3=Dev_y*(Yd/50)
6950    IF N>0 THEN 7520
6960    PLOTTER IS 13,"GRAPHICS"
6970    GRAPHICS
6980    LOCATE 0,110,0,110
6990    CLIP 0,13,0,100
7000    FRAME
```

```
7010    UNCLIP
7020    SCALE Xmn-Xd*.25,Xmx+Xd*.05,Ymn-Yd*.10,Ymx+Yd*.15
7030    CLIP Xmn-Xd*.25,Xmn-Xd*.10,Ymn,Ymx
7040    AXES 10,Yd/20,Xmn-Xd*.25,Ymn,50,2
7050    CLIP Xmn,Xmx,Ymn,Ymx
7060    Xtic=Xd/10
7070    Ytic=Yd/10
7080    AXES Xtic,Ytic,Prx,Pry,10,10
7090    FRAME
7100    UNCLIP
7110    MOVE Xmx+Xd*.01,Ymn
7120    LABEL USING "K";X$
7130    DEG
7140    LDIR 0
7150    LORG 1
7160    MOVE Xmn,Ymx+Yd*.01
7170    LABEL USING "K";Y$
7180    LORG 2
7190    FOR J=1 TO 10 STEP 1
7200    MOVE Xmn-Xd*.23,Ymn+J*(Yd/10)
7210    LABEL USING "K";J*5
7220    NEXT J
7230    LDIR 0
7240    LORG 6
7250    CSIZE 3,.5
7260    MOVE Prx,Ymn-Yd*.01
7270    LABEL USING "DDDDD.DD";Prx
7280    LDIR 270
7290    LORG 6
7300    CSIZE 3,.5
7310    MOVE Xmn-Xd*.01,Pry
7320    LABEL USING "DDDDD.DD";Pry
7330    MOVE Xmn-Xd*.25,Ymn
7340    DRAW Xmn-Xd*.10,Ymn
7350    LDIR 0
7360    LORG 6
7370    MOVE Xmn-Xd*.2,Ymn-Yd*.009
7380    LABEL USING "K";"wx"
7390    MOVE Xmn-Xd*.16,Ymn-Yd*.009
7400    LABEL USING "K";"xy"
7410    MOVE Xmn-Xd*.12,Ymn-Yd*.009
7420    LABEL USING "K";"yz"
7430    MOVE Xmn-Xd*.18,Ymn
7440    DRAW Xmn-Xd*.18,Ymn+Cb
7450    MOVE Xmn-Xd*.16,Ymn
7460    DRAW Xmn-Xd*.16,Ymn+Cb2
7470    MOVE Xmn-Xd*.12,Ymn
7480    DRAW Xmn-Xd*.12,Ymn+Cb3
7490    LINE TYPE 1
7500    MOVE Xmn,Pry+Mp*(Xmn-Prx)
7510    DRAW Xmx,Pry+Mp*(Xmx-Prx)
7520    LINE TYPE 2
7530    MOVE Xplot,Yplot
7540    DRAW Xplot,Yplot
7550    IF N=0 THEN Xplot=Xmn
7560    IF N=0 THEN Yplot=Ymn
7570    POINTER Xplot,Yplot,2
7580    IF N>0 THEN 7600
7590    GOTO 7750
7600    LINE TYPE 1
7610    PEN -1
7620    MOVE Xmn-Xd*.18,Ymn
7630    DRAW Xmn-Xd*.18,Ymn+Lcb
7640    MOVE Xmn-Xd*.16,Ymn
7650    DRAW Xmn-Xd*.16,Ymn+Lcb2
7660    MOVE Xmn-Xd*.12,Ymn
```

```
7670     DRAW Xmn-Xd*.12,Ymn+Lcb3
7680     PEN 1
7690     MOVE Xmn-Xd*.18,Ymn
7700     DRAW Xmn-Xd*.18,Ymn+Cb
7710     MOVE Xmn-Xd*.16,Ymn
7720     DRAW Xmn-Xd*.16,Ymn+Cb2
7730     MOVE Xmn-Xd*.12,Ymn
7740     DRAW Xmn-Xd*.12,Ymn+Cb3
7750     PEN 1
7760     Lcb=Cb
7770     Lcb2=Cb2
7780     Lcb3=Cb3
7790 SUBEND
7800 SUB St(O(*),N,Stat(*),Cov(*),O_set(*))
7810 DEFAULT ON
7820 OPTION BASE 1
7830 DIM Var(4),X(4)
7840 IF N>1 THEN Jump
7850 MAT O_set=O
7860 MAT Stat=(0)
7870 MAT Cov=(0)
7880 MAT Var=(0)
7890 Jump:FOR I=1 TO 4
7900  X(I)=O(I)
7910 X(I)=X(I)-O_set(I)
7920 Stat(1,I)=Stat(1,I)+X(I)     !Cumulative sum
7930 Stat(2,I)=Stat(2,I)+X(I)^2   !Sum^2
7940 Stat(3,I)=Stat(1,I)/N        !Ave
7950 Var(I)=Stat(2,I)/N-Stat(3,I)^2
7960 IF Var(I)<0 THEN Next
7970 Stat(4,I)=SQR(Var(I))
7980 Next:!
7990 NEXT I
8000 Cov(1,1)=Cov(1,1)+X(1)*X(2)
8010 Cov(1,2)=Cov(1,2)+X(1)*X(3)
8020 Cov(1,3)=Cov(1,3)+X(1)*X(4)
8030 Cov(1,4)=Cov(1,4)+X(2)*X(3)
8040 Cov(1,5)=Cov(1,5)+X(2)*X(4)
8050 Cov(1,6)=Cov(1,6)+X(3)*X(4)
8060 Cov(2,1)=Cov(1,1)/N-Stat(3,1)*Stat(3,2)
8070 Cov(2,2)=Cov(1,2)/N-Stat(3,1)*Stat(3,3)
8080 Cov(2,3)=Cov(1,3)/N-Stat(3,1)*Stat(3,4)
8090 Cov(2,4)=Cov(1,4)/N-Stat(3,2)*Stat(3,3)
8100 Cov(2,5)=Cov(1,5)/N-Stat(3,2)*Stat(3,4)
8110 Cov(2,6)=Cov(1,6)/N-Stat(3,3)*Stat(3,4)
8120 Cov(3,1)=Cov(2,1)/(Stat(4,1)*Stat(4,2))
8130 Cov(3,2)=Cov(2,2)/(Stat(4,1)*Stat(4,3))
8140 Cov(3,3)=Cov(2,3)/(Stat(4,1)*Stat(4,4))
8150 Cov(3,4)=Cov(2,4)/(Stat(4,2)*Stat(4,3))
8160 Cov(3,5)=Cov(2,5)/(Stat(4,2)*Stat(4,4))
8170 Cov(3,6)=Cov(2,6)/(Stat(4,3)*Stat(4,4))
8180 SUBEND
8190 SUB Reg(Stat(*),Cov(*),S(*),R(*),Offset(*))
8200 OPTION BASE 1
8210 DEFAULT ON
8220 S(1,1)=S(1,2)=S(1,3)=Stat(3,1)+Offset(1)
8230 S(1,4)=S(1,5)=Stat(3,2)+Offset(2)
8240 S(1,6)=Stat(3,3)+Offset(3)
8250 S(2,1)=Stat(3,2)+Offset(2)
8260 S(2,2)=S(2,4)=Stat(3,3)+Offset(3)
8270 S(2,3)=S(2,5)=S(2,6)=Stat(3,4)+Offset(4)
8280 S(3,1)=S(3,2)=S(3,3)=Stat(4,1)
8290 S(3,4)=S(3,5)=Stat(4,2)
8300 S(3,6)=Stat(4,3)
8310 S(4,1)=Stat(4,2)
8320 S(4,2)=S(4,4)=Stat(4,3)
```

```
8330 S(4,3)=S(4,5)=S(4,6)=Stat(4,4)
8340 FOR I=1 TO 6
8350 Ind_var:!
8360 Iv=1
8370 D=2
8380 IF S(4,I)>S(3,I) THEN Iv=2
8390 IF S(4,I)>S(3,I) THEN D=1
8400 R(3,I)=Iv
8410 Slope:!
8420 R(1,I)=Cov(3,I)*S(D+2,I)/S(Iv+2,I)
8430 IF Iv=2 THEN R(1,I)=1/R(1,I)
8440 Residual:!
8450 C=1-Cov(3,I)^2
8460 IF C<0 THEN 8480
8470 R(2,I)=S(D+2,I)*C^.5
8480 NEXT I
8490 SUBEND
8500 SUB Pstats(Stats(*),O_set(*),Cov(*),R(*),Sample)
8510  OPTION BASE 1
8520   PRINT "____________________________________________________________________
_______________"
8530   PRINT LIN(1);TAB(21);"(TDW)";TAB(36);"(TDX)";TAB(51);"(TDY)";TAB(66);"(TD
Z)"
8540   FIXED 3
8550   PRINT LIN(1);TAB(1);"CUMULATIVE AVERAGE";TAB(20);Stats(3,1)+O_set(1);TAB(
35);Stats(3,2)+O_set(2);TAB(50);Stats(3,3)+O_set(3);TAB(65);Stats(3,4)+O_set(4)
8560   PRINT LIN(1);TAB(1);"STANDARD DEVIATION";TAB(20);Stats(4,1);TAB(35);Stats
(4,2);TAB(50);Stats(4,3);TAB(65);Stats(4,4)
8570   PRINT LIN(2);TAB(25);"(WX)";TAB(44);"(WY)";TAB(64);"(WZ)"
8580   PRINT LIN(1);TAB(1);"CORRELATION COEFFICENT";TAB(24);Cov(3,1);TAB(43);Cov
(3,2);TAB(63);Cov(3,3)
8590   PRINT LIN(1);TAB(1);"REGRESSION LINE SLOPE";TAB(24);R(1,1);TAB(43);R(1,2)
;TAB(63);R(1,3)
8600   PRINT LIN(1);TAB(1);"RESIDUAL";TAB(24);R(2,1);TAB(43);R(2,2);TAB(63);R(2,
3)
8610   STANDARD
8620   PRINT LIN(1);TAB(1);"INDEPENDENT VARIABLE";TAB(24);R(3,1);TAB(43);R(3,2);
TAB(63);R(3,3)
8630   FIXED 3
8640   PRINT LIN(2);TAB(25);"(XY)";TAB(44);"(XZ)";TAB(64);"(YZ)"
8650   PRINT LIN(1);TAB(1);"CORRELATION COEFFICENT";TAB(24);Cov(3,4);TAB(43);Cov
(3,5);TAB(63);Cov(3,6)
8660   PRINT LIN(1);TAB(1);"REGRESSION LINE SLOPE";TAB(24);R(1,4);TAB(43);R(1,5)
;TAB(63);R(1,6)
8670   PRINT LIN(1);TAB(1);"RESIDUAL";TAB(24);R(2,4);TAB(43);R(2,5);TAB(63);R(2,
6)
8680   STANDARD
8690   PRINT LIN(1);TAB(1);"INDEPENDENT VARIABLE";TAB(24);R(3,4);TAB(43);R(3,5);
TAB(63);R(3,6)
8700   PRINT LIN(1);"SAMPLES=";Sample
8710   PRINT "____________________________________________________________________
_______________"
8720   PRINT LIN(1)
8730   SUBEND
8740   SUB Graf(Xmn,Xmx,Ymn,Ymx,Mp,Xaxes,Yaxes,Prx,Pry)
8750   STANDARD
8760   READ Xaxes,Yaxes,Xmn,Xmx,Ymn,Ymx,Prx,Pry,Mp
8770   DATA 2,3,26135.00,26136.00,43995.00,43996.00,26135.72,43995.36,0
8780   RESTORE 8770
8790   GOTO 8890
8800   INPUT "Input what you want on the X-axes ? :1=W,2=X,3=Y,4=Z",Xaxes
8810   INPUT "Input what you want on the Y-axes ? :1=W,2=X,3=Y,4=Z",Yaxes
8820   INPUT "Input X-MIN: 26135.00 ?",Xmn
8830   INPUT "Input X-MAX: 26136.00 ?",Xmx
8840   INPUT "Input Y-MIN: 43995.00 ?",Ymn
8850   INPUT "Input Y-MAX: 43997.00 ?",Ymx
```

```
8860   INPUT "Input X-PREDICTED:26135.66 ?",Prx
8870   INPUT "Input Y-PREDICTED:43995.77 ?",Pry
8880   INPUT "Input predicted SLOPE :1 ?",Mp
8890   PRINTER IS 16
8900   PRINT "X-axes=";Xaxes
8910   PRINT "Y-axes=";Yaxes
8920   PRINT "Xmin=";Xmn
8930   PRINT "Xmax=";Xmx
8940   PRINT "Ymin=";Ymn
8950   PRINT "Ymax=";Ymx
8960   PRINT "PREDICTED X=";Prx
8970   PRINT "PREDICTED Y=";Pry
8980   PRINT "SLOPE IS=";Mp
8990   INPUT "Are the graphic parameters displayed above correct ?:Y or N ?",Dta
$
9000   IF Dta$<>"Y" THEN 8800
9010   OUTPUT 9;"R"
9020   ENTER 9;At$
9030   PRINTER IS 0
9040   PRINT "X-AXES =";Xaxes
9050   PRINT "Y-AXES =";Yaxes
9060   PRINT "X-AXES";Xmn,Prx,Xmx
9070   PRINT "Y-AXES";Ymn,Pry,Ymx
9080   PRINT "SLOPE=";Mp
9090   PRINT "DATE IS ";At$
9100   SUBEND
9110   SUB Triangle(Sa,Sb,Sc,A,B,C)
9120   INTEGER E
9130   DEG
9140   S=(Sa+Sb+Sc)/2
9150   ON ERROR GOTO 9170
9160   GOTO 9190
9170  PRINT "ERROR 25";A;S;Sa;Sb;Sc
9180  SUBEXIT
9190   A=ACS(2*S*(S-Sa)/(Sb*Sc)-1)
9200   D=Sa/SIN(A)
9210   B=ASN(Sb/D)
9220   C=ASN(Sc/D)
9230   OFF ERROR
9240   E=A+B+C
9250   IF (A<90) AND (E<>180) THEN Alt
9260   SUBEXIT
9270 Alt:    IF Sb<Sc THEN Alt2
9280   B=180-B
9290   E=A+B+C
9300   SUBEXIT
9310 Alt2:    C=180-C
9320   E=A+B+C
9330  SUBEND
9340  SUB Position(Zo(*),Alpha,Sc,Sign,B,Z(*))
9350  DEG
9360  OPTION BASE 1
9370  Theta=Alpha+Sign*B
9380  Z(1)=Zo(1)+Sc*SIN(Theta)
9390  Z(2)=Zo(2)+Sc*COS(Theta)
9400  SUBEND
9410  SUB Plot_xy(Sample,Wp_x,Wp_y,Ap(*),R)
9420  Ax(1)=Ap(1)
9430  Ay(1)=Ap(2)
9440  Minx=Wp_x-R
9450  Maxx=Wp_x+R
9460  Miny=Wp_y-R
9470  Maxy=Wp_y+R
9480  T=2
9490  N=Sample
9500  IF N=1 THEN 9830
```

```
9510  IF Sample>0 THEN 9790
9520  PLOTTER IS 13,"GRAPHICS"
9530  GRAPHICS
9540  LOCATE 10,100,10,100
9550  FRAME
9560  SCALE Minx,Maxx,Miny,Maxy
9570  AXES .1,.1,Wp_x,Wp_y,10,10
9580  MOVE Ax(1),Ay(1)
9590  SUBEXIT
9600  DEG
9610  MOVE Minx,Miny
9620  LABEL USING "K";Minx
9630  LORG 3
9640  MOVE Maxx,Miny
9650  LABEL USING "K";Maxx
9660  LORG 8
9670  LDIR 0
9680  MOVE Minx,Wp_y
9690  LABEL USING "K";Wp_y
9700  LORG 7
9710  MOVE Minx,Miny
9720  LABEL USING "K";Miny
9730  LORG 9
9740  MOVE Minx,Maxy
9750  LABEL USING "K";Maxy
9760  MOVE Sx1,Sy1
9770  Ax(1)=Sx1
9780  Ay(1)=Sy1
9790  LINE TYPE 1
9800  DRAW Ax(1),Ay(1)
9810  POINTER Ax(1),Ay(1)
9820  GOTO 9850
9830  MOVE Ax(1),Ay(1)
9840  POINTER Ax(1),Ay(1)
9850  PRINTER IS 0
9860  SUBEND
9870  !
9880  SUB Plot_ct(Ct,At,R,N)
9890  IF N>0 THEN Plot
9900  K=1
9910  Ct=0
9920  At=0
9930  PLOTTER IS 13,"GRAPHICS"
9940  GRAPHICS
9950  LOCATE 20,80,10,100
9960  SCALE -.2,.2,-.2,R
9970  AXES .01,.1,0,0,10,10
9980  SUBEXIT
9990 Plot:  POINTER Ct,At
10000 IF N=1 THEN 10030
10010 DRAW Ct,At
10020 SUBEXIT
10030 MOVE Ct,At
10040 POINTER Ct,At
10050 K=0
10060 SUBEND
10070 SUB Debug(A$,Bug$(*),Bug_com,Bug_count)
10080 IF Bug_count>38 THEN 10110
10090 A$=Bug$(Bug_count)
10100 SUBEXIT
10110  Bug_com=0
10120 SUBEND
```

APPENDIX E

LOADING AUSTRON PROGRAMS

LOADING THE AUSTRON 5000 PROGRAM FROM THE 9845 AT 300 BAUD

1. Secure all power.
2. Set M8655 Module in PDP8/E to Code 0304, 300 baud.
3. Connect cable to the M8655 module and the RS-232C from the 9845 computer.
4. Set RS-232C bit rate switch to 300 baud (position 7).
5. Set interface select code on the RS-232C to position (10).
6. Energize AUSTRON 5000 system and 9845 computer.
7. Load bootstrap and check for validity.
8. Load program "LOAD30" into 9845 computer.
9. Push run on 9845 and wait for 3 beeps, then hit CLEAR/CONT on the PDP8/E.
10. When program is loaded (12 minutes), set address 0200.
11. Load program "SURVEY" into 9845 computer.
12. Push RUN on 9845 computer.
13. Hit CLEAR/CONT on AUSTRON 5000 system.
14. The following AUSTRON test data should appear on 9845 computer.

    AUSTRON SYSTEM 500

    LORAN-C MONITOR TEST VERSION 2/8/77

15. Set up AUSTRON 5000 system in accordance with the AUSTRON command dictionary (appendix A).

LOADING THE AUSTRON 5000 PROGRAM FROM THE 9845 AT 9600 BAUD

1. Secure all power.
2. Set M8655 control card to Code 0304 and 9600 baud.
3. Connect cable to the M8655 module and the RS-232C interface from the 9845 computer.
4. Set the RS-232C bit rate switch to 9600 baud rate position (position 10).
5. Set interface select code on the RS-232C to position 10.
6. Energize AUSTRON 5000 system and 9845 computer.
7. Load bootstrap and check for validity.

   NOTE: MAKE SURE YOU ARE AT FIELD Ø FOR LOADING BOOTSTRAP.

8. Load "LOAD96" into 9845 computer.
9. Push run on 9845 computer and wait for 3 beeps, then press CLEAR/CONT on the PDP8/E. (Lights will come on as the 300-baud rate order, only the load time is 30 seconds instead of 12 minutes.)
10. After program is loaded, go to address 0200.
11. Load "SURVEY" program into 9845 computer; hit RUN.
12. When 9845 is ready, set address 0200 on PDP8/E and hit CLEAR/CONT.
13. The following AUSTRON test data should appear on 9845 computer.

    AUSTRON SYSTEM 500

    LORAN-C MONITOR TEST VERSION 2/8/77

15. Set up AUSTRON system in accordance with AUSTRON command dictionary.

PDP8/E LIGHT INDICATIONS WHILE LOADING AUSTRON PROGRAM (300 BAUD)

1. Load bootstrap (switch in "MD" position).
2. M8655 card set to 0304 code.
3. Verify bootstrap (examine switch).
4. Set address 0030 (switch in "STATUS" position).
5. When program is loading, the "LINK" light will blink.
6. When loading, the RUN light should be lit.
7. After start of load process, the address lamps should indicate 7675 after 18 to 28 seconds.
8. After 3 minutes and 40 seconds, the DF2 lamp should light.
9. After 8 minutes, the DF1 lamp should light.
10. After 12 minutes, the address lamps should indicate 7777.
11. Program is loaded, RUN light is out.

NOTE: AT 9600 BAUD, THIS PROCESS TAKES 30 SECONDS.

APPENDIX F

"P-LOAD" PROGRAM LISTING

```
1     ! THIS PROGRAM IS CALLED "LOAD30"
10    ! THIS PROGRAM READS THE AUSTRON 5000 MONITOR DATA FROM THE HP-9845 TAPE.
20    ! THEN SENDS IT TO THE PDP-8. WHERE IT IS LOADED INTO THE PDP-8.
30    ! C$ CONSIST OF THE ASCII CODE PROGRAM FOR THE AUSTRON 5000 MONITOR SYSTEM.
40    DIM C$[16897]                   ! THIS IS THE EXACT SIZE OF THE MONITOR PROG.
50    ASSIGN #1 TO "C$"
60    READ #1,1
70    READ #1;C$                      ! READS C$(DATA) FROM 9845 TAPE.
80    CALL Write_control(0)
90    OUTPUT 10 USING "#,B";8
100   WAIT 200
110   OUTPUT 10 USING "#,B";37
120   WAIT 200
130   CALL Write_control(0)
140   OUTPUT 10 USING "#,B";64
150   OUTPUT 10 USING "#,B";207 ! SETS BAUD RATE. RATE IS 300 BAUD.
160   OUTPUT 10 USING "#,B";37
170   CALL Write_control(1)
180   OUTPUT 10 USING "#,B";8
190   OUTPUT 10 USING "#,B";39
200   CALL Write_control(0)
210   CALL Write_control(1)           ! SETS UP THE RS-232 INTERFACE.
220   OUTPUT 10 USING "#,B";39        ! MAKES THE HP-9845 A TRANSMITTER.
230   CALL Write_control(0)
240   WRITE IO 10,6;1                 ! WRITE TO THE IO.
250   PRINTER IS 10                   ! MAKES THE RS-232 LOOK LIKE A RECEIVER.
260   BEEP
270   WAIT 1000
280   BEEP
290   WAIT 1000
300   BEEP
310   WAIT 10000  ! AFTER 3 BEEPS, YOU HAVE 10 SECONDS TO HIT, CLEAR, CONT, ON
                    THE PDP8/E. TO LOAD PROGRAM FROM HP-9845.
320   OUTPUT 10 USING "#,K";C$
350   END
360   SUB Write_control(Control_word)
370   CONTROL MASK 10;Control_word
380   IF NOT IOFLAG(10) THEN 380
390   WRITE IO 10,5;Control_word
400   SUBEND
```

```
10    ! THIS PROGRAM IS CALLED "LOAD96"
20    ! THIS PROGRAM READS THE AUSTRON 5000 MONITOR DATA FROM THE HP-9845 TAPE.
30    ! THEN SENDS IT TO THE PDP-8. WHERE IT IS LOADED INTO THE PDP-8.
40    ! C$ CONSIST OF THE ASCII CODE PROGRAM FOR THE AUSTRON 5000 MONITOR SYSTEM.
50    DIM C$[18897]                  ! THIS IS THE EXACT SIZE OF THE MONITOR PROG.
60    ASSIGN #1 TO "C$"
70    READ #1,1
80    READ #1;C$                     ! READS C$(DATA) FROM 9845 TAPE.
90    CALL Write_control(0)
100   OUTPUT 10 USING "#,B";8
110   WAIT 200
120   OUTPUT 10 USING "#,B";37
130   WAIT 200
140   CALL Write_control(0)
150   OUTPUT 10 USING "#,B";64
160   OUTPUT 10 USING "#,B";206 ! SETS BAUD RATE. RATE IS 9600 BAUD.
170   OUTPUT 10 USING "#,B";37
180   CALL Write_control(1)
190   OUTPUT 10 USING "#,B";8
200   OUTPUT 10 USING "#,B";39
210   CALL Write_control(0)
220   CALL Write_control(1)          ! SETS UP THE RS-232 INTERFACE.
230   OUTPUT 10 USING "#,B";39       ! MAKES THE HP-9845 A TRANSMITTER.
240   CALL Write_control(0)
250   WRITE IO 10,5;1                ! WRITE TO THE IO.
260   PRINTER IS 10                  ! MAKES THE RS-232 LOOK LIKE A RECEIVER.
270   BEEP
280   WAIT 1000
290   BEEP
300   WAIT 1000
310   BEEP
320   WAIT 10000   ! AFTER 3 BEEPS, YOU HAVE 10 SECONDS TO HIT, CLEAR, CONT, ON
                     THE PDP8/E. TO LOAD PROGRAM FROM HP-9845.
330   OUTPUT 10 USING "#,K";C$
340   END
350   SUB Write_control(Control_word)
360   CONTROL MASK 10;Control_word
370   IF NOT IOFLAG(10) THEN 370
380   WRITE IO 10,5;Control_word
390   SUBEND
```

APPENDIX G

CALCULATION OF VESSEL POSITION

CALCULATION OF VESSEL POSITION USING MINIRANGER

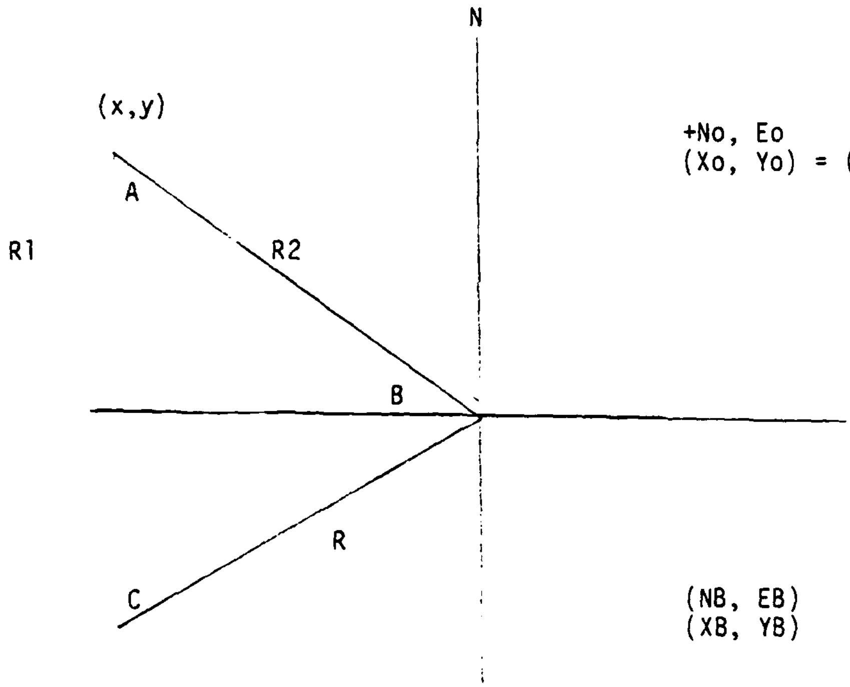


FIGURE G-1. REFERENCE TRIANGLE

Definitions:

$\triangle A,B,C$	=	Triangle formed by survey vessel and two Miniranger reference stations; A is vessel, B and C labeled clockwise from A
α	=	Azimuth between reference stations (B to C)
R	=	Range between reference stations (B to C)
R_1	=	Range from reference station to vessel (C to A)
R_2	=	Range from reference station to vessel (B to A)
N_B, E_B	=	State-plane coordinates of reference station (B)
N_C, E_C	=	State-plane coordinates of reference station (C)
x_B, y_B	=	*Local grid coordinates of reference station* (B)
x, y	=	Local grid coordinates of vessel (A)
No,Eo	=	State-plane coordinates of local grid origin
Sign	=	+1 or -1 depending on which side of the baseline (B to C) the vessel is

Calculation of vessel's local grid coordinates:

Given: N_O, E_O
N_B, E_B
N_C, E_C

Measure: R_1, R_2

Solution:

- Calculate local grid coordinates of reference station (B)

$$x_B = E_B - E_O$$

$$y_B = N_B - N_O$$

- Calculate azimuth and range between reference stations

$$\alpha = ATN((E_C-E_B)/(N_C-N_B))$$

If $(N_C-N_B) < 0$ then $\alpha = \alpha + 180$

If $\alpha < 0$ then $\alpha = \alpha + 360$

$$R = SQR\ ((E_C-E_B)^2 + (N_C-N_B)^2$$

- Calculate angles of $\triangle$ formed by vessel and two transponders using low of sines[1]

$$S = (R + R1 + R2)/2$$

$$A = \angle A = ACS(2_1*S*(S-R)/(R1*R2)-1)$$

$$D = R/SIN(A)$$

$$B = \angle B = ASN\ (R1/D)$$

$$C = \angle C = ASN(R2/D)$$

If $A < 90^o$ and $A+B+C \neq 180$ then either B or C is greater than 90^o

The larger angle will be opposite the longer side:

if $R1 < R2$ then $C = 180 - C$, $B = B$

if $R2 < R1$ then $B = 180 - B$, $C = C$

- Calculate local grid coordinates of vessel:

$$x = x_B + R2 \sin\ (\alpha + sign * B)$$

$$y = y_B + R2 \cos\ (\alpha + sign * B)$$

Sign is normally 1; if the baseline is crossed then sign switches to -1

Considerations:

- The Miniranger range measurements are slant range, any significant difference in heights between the master and remote transponders must be considered. The difference between slant range (R) and true range (R+) is a function of the difference in height between transponder (h) and the separation between transponders (Rt)[1].

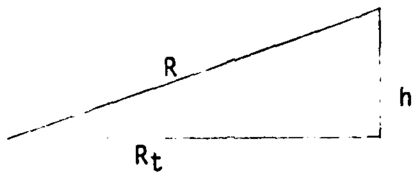


FIGURE G-2. RANGE TRIANGLE

$$Rt = SQR\ (R^2 - h^2)$$

$$= R - \frac{h^2}{2R} - \frac{h^4}{8R^3} - \frac{h^6}{16R^5} - \ \cdots$$

$$\text{error} = e = R - R_t \approx \frac{h^2}{2R}$$

NOTE: If maximum allowable error is 1M at 2000M,

$$1 = \frac{h^2}{2(2000)}\ ;\ h^2 = 4000;\ h = 63M$$

i.e., difference in height should be less than 63M.

- The correction to change horizontal distance from a cord distance to an arc distance in the surface of a spheroid is a function of the distance[1].

$$K \simeq 1.027\ H^3 \times 10^{-15}$$

for $K \leq 1M$

$H \leq 99 \quad 115$ KM

For our purposes, this correction is not significant.

- The correction to change horizontal distances at the mean elevation of the transponders to the horizontal distance at mean sea level is [1].

$$C \simeq -R\ \frac{h}{6{,}390{,}000}$$

for C = 1M and R = 5000

$$h = \frac{1 \times 6{,}390{,}000}{5000} = 1278M$$

Again, this is not a significant factor for our purposes.

- Until proven otherwise, the calibration of the Miniranger transponders should be checked daily before and after data collection.

- The vessel position solution assumes a planar geometry. This assumption holds if the area of the triangle is less than 75 square miles[1].

for a right triangle with R1=R2

$$\text{Area} = 1/2\ R1^2$$

if Area = 75 mi^2

$$R1^2 = \sqrt{150} = 12.25 \text{ miles}$$

- The accuracy of position determined from a single measurement of two ranges is a function of the crossing angles of the LOPs and the accuracy of the range measurement (assuming that any bias errors have been eliminated during calibration).

$$\sigma_{\text{radial error}} = \frac{1.414}{\sin A}\ \sigma_r$$

Typical σ_r = 1M

A (deg)	σ_{error}(M)
90	1.4
60	1.6
45	1.63
30	2.8
15	5.5
10	8.1

[1]Surveying Computers Manual, TM 5-237, October 1964, Department of Army.

Calculation in program "SURVEY"

- Calculation of reference station Bs local coordinates and the range and azimuth between reference stations is done in the subroutine Data_coll.

- The subprogram, Triangle, calculates the angles A,B,C.

- The subprogram, Position, calculates the local grid coordinates of the vessel.

APPENDIX H

STATISTICS CALCULATIONS

STATISTICS CALCULATIONS, SUBPROGRAM
St(O(*), N, Stat(*), Cov(*), O_set(*))

This subprogram calculates cumulative sum, sum of squares, mean, standard deviation, sums of cross products, covariances, and correlation coefficients for four variables.

Inputs are:

O(*) - current sample (4x1)

N - sample number

Outputs are:

O_set(*) - The first data sample which is subtracted from succeeding samples to eliminate roundoff error in standard deviation and covariance calculations.

Stat(*) - A summary statistics array for the dummy variable X(*) where X(*) = O(*) - O_set(*).

Note:

Mean O(i) = Mean X(i) + O_set(i), i=1 to 4
Standard deviation O(i) = Standard deviation X(i), i=1 to 4
Covariance O(i)O(j) = covar X(i)X(j), i=1 to 4

Entries in Stat(*) are:

$$Stat(1,i) = \sum_{1}^{N} x(i), \quad i = 1 \text{ to } 4$$

$$Stat(2,i) = \sum_{1}^{N} x^2(i), \quad i = 1 \text{ to } 4$$

$$Stat(3,i) = \sum^{N} x(i)/N, \quad i = 1 \text{ to } 4$$

$$Stat(4,i) = \left(\sum x^2(i)/N - \left(\sum x(i)/N\right)^2\right)^{1/2}$$

Cov(*) - A summary covariance array for the dummy variable X(*).

Entries in Cov(*) are:

$$\sum^{N} X(1)X(2),\ \sum^{N} X(1)X(3),\ \sum^{N} X(1)X(4),\ \sum^{N} X(2)X(3),\ \sum^{N} X(2)X(4),\ \sum^{N} X(3)X(4)$$

cov X(1)X(2), cov X(1)X(3), cov X(1)X(4), cov X(2)X(3), cov X(2)X(4), cov X(3)X(4)

r_{12}, r_{13}, r_{14}, r_{23}, r_{24}, r_{34}

where:

$$\text{cov } X(i)X(j) = \quad X(i)X(j)/N - \sum X(i) \sum X(j)$$

$$r_{ij} = \text{cov } X_i\ X_j/(\sigma_{X_i} * \sigma_{X_j})$$

APPENDIX I

LINEAR REGRESSION CALCULATIONS

LINEAR REGRESSION CALCULATIONS, SUBPROGRAM
Reg(Stat(*), Cov(*), S(*), R(*), Offset (*))

This suoprogram calclates linear regression coefficients and residuals for pairs of four variables. This program is supported by the subprogram St(O(*), N, Stat(*), Cov(*), O_set(*)).

Inputs are:

Stat(*) - A summary statistics array which contains the cumulative sum, sum of sqaures, mean, and standard deviation of four variables. (See appendix __.)

Cov(*) - A summary statistics array which contains the cumulative sum of crossproducts, covariance, and correlation coefficient for each pair of variables. (See appendix __.)

Offset(*) - The first data sample which is subtracted from succeeded data samples to prevent round-off error in standard deviation and covariance calculations. (See appendix __.)

Outputs are:

S(*) - A 6x4 array which contains the means and standard deviations for each pair of variables. Entries are

M_1	M_1	M_2	M_2	M_2	M_3
M_2	M_3	M_4	M_3	M_4	M_4
σ_1	σ_1	σ_2	σ_2	σ_2	σ_3
σ_2	σ_3	σ_4	σ_3	σ_4	σ_4

where

M_i = mean of the ith variable
σ_i = standard deviation of the ith variable

R(*) - A 6x3 array which contains the linear regression slope, RMS residuals, and definition of independent variable. Entries are:

S_{12}	S_{13}	S_{14}	S_{23}	S_{24}	S_{34}
R_{12}	R_{13}	R_{14}	R_{23}	R_{24}	R_{34}
I_{12}	I_{13}	I_{14}	I_{23}	I_{24}	I_{34}

where

S_{ij} is the slope of the jth variable with respect to the ith variable.

R_{ij} is the rms residuals of the linear regression of variables i and j.

I_{ij} indicates which variable is used as the independent variable in the calculations; if $I_{ij} = 1$, the i = independent variable; if $I_{ij} = 2$, then j = independent variable.

The linear regression of the variable y onto the variable x can be expressed in the following form:

$$(y-\bar{y}) = m\ (x-\bar{x})$$

where y is the dependent variable
x is the independent variable
$\bar{y}$ is the mean of the dependent variable
$\bar{x}$ is the mean of the independent variable
m is the regression line slope = $r_{xy}\sigma_y/\sigma_x$
r_{xy} is the correlation coefficient
σ_y is the standard deviation of the dependent variable
σ_x is the standard deviation of the independent variable

In the program, the variable with the larger standard deviation is chosen as the independent variable for calculating slope. However, the value, S_{ij}, stored in the array R(*), i.e.,

$$R_{1i};\ i = 1 \text{ to } 6$$

is the slope of the jth variable with respect to ith variable. If the jth variable is the independent variable, the slope is inverted before being stored in R(*). The value stored in R_{3i} indicates which variable is the independent variable for the linear regression calculations.

The residual is calculated using the following expression.

$$\text{Residual} = \sigma_{\text{dependent variable}}\ (1-r^2)^{1/2}$$

It is a measure of how well the linear regression line fits the data.

APPENDIX J

SURVEY PROGRAM VARIABLE LIST

VARIABLE LIST

Data Communications Arrays

Buf$(*)(Kbd$(*)) - Stores keyboard entries when the keyboard is in the teletype mode.

Dcom$(*) - Stores data from the Austron 5000 (via TBUF$) until it can be processed by the program.

A$(*) - Message to be transmitted to Austron 5000.

B$(*) - Message received from the Austron 5000.

Bug$(*) - Program patch for Austron 5000.

TBUF$ - Stores data from Austron 5000.

Data Communications Variables and Flags

Cursor - Transmit data to Austron flag.

Sel_code - Select code for RS232 interface.

Command - Transmit data to Austron flag

Bug_com - Transmit Austron 5000 program patch flag

Kbd - Flag to switch from teletype to calculator keyboard mode switch = not kbd and cursor.

Data Arrays and Variables

Td(*) - TD sample.

Time$ - Time sample.

Sample - Sample number.

Set - Data set number, increments every 100 samples.

R1 - Range 1 sample.

R2 - Range 2 sample.

A1(*), A2(*), A3(*), A4(*) - TDW data.

B1(*), B2(*), B3(*), B4(*) - TDX data.

C1(*), C2(*), C3(*), C4(*) - TDY data.

D1(*), D2(*), D3(*), D4(*) - TDZ data.

E1(*), E2(*), E3(*), E4(*) - Range 1 data.

F1(*), F2(*), F3(*), F4(*) - Range 2 data.

T1$(*), T2$(*), T3$(*), T4$(*) - Time data.

Miniranger Variables

Range_1 - Code word for R1 transponder.

Range_2 - Code word for R2 transponder.

R1 - Range measured to R1 transponder.

R2 - Range measured to R2 transponder.

Mrs - 0 = collecting Miniranger data.
      1 = not collecting Miniranger data.

Ra - Side opposite angle A, baseline between reference stations.

Rb - Side opposite angle B.

Rc - Side opposite angle C.

A - Angle at vessel.

B - Angle clockwise from vessel.

C - Angle counterclockwise from vessel.

Zo(*) - Position of reference station at B in local coordinates.

Alpha - Azimuth of baseline (B to C).

R - Baseline distance.

Sign - Sign to be applied to angle B for calculating vessel position, normally equals +1.

Z(*) - Position of vessel in local coordinates.

X1,Y1 - Position of start point for along/cross track calculations.

X2,Y2 - Position of stop point for along/cross track calculations.

Course - Bearing between start and stop points.

At,Ct - Along and cross track distance.

Rf1 - Previous R1 range sample.

Rf2 - Previous R2 range sample.

Ref$(*) - Reference station list.

Ref$(*) - Reference station positions.

Tp$ - Location of transponder #1.

TP - Flag to indicate where reference station R1 is located.

Statistics Variables

Td(*) - TD sample.

Sample - Sample number.

Stats(*) - Statistics summary array (see Appendix __).

Cov(*) - Statistics summary array (see Appendix __).

O_set(*) - Offset array (see Appendix __).

S(*) - Statistics summary array (see Appendix __).

R(*) - Regression summary array (see Appendix __).

Data Collection Control Variables and Flags

Data Collect - Data initialization flag set by Data_col.

Data - Data collect flag; set by START.

Dp - Data pointer.

Set - Data set number; increments every 100 samples.

Sample - Sample number.

Stp - Stop data collection flag, set by STOP.

Pause - Pause data collection flag, set by PAUSE.

Mrs - Miniranger data collection flag; set during data collection initialization

0 indicates Miniranger data to be collected.
1 indicates no Miniranger data.

Plott - Type of plot desired, 1 = TD plot; 2 = CT/AT; 3 = xy.

Plot$ - Plot data flag "Y" = plot, "N" = no plot.

Plotting Variables

TD plot

TD(*) - TD sample.

Sample - Sample number.

Xmn, Xmx - X-axis minimum and maximum.

Ymn, Ymx - Y-axis minimum and maximum.

Mp - Predicted regression line slope.

Xaxes, Yaxes - Axes label for data to be plotted in X and Y axes, e.g., TDW, TDX, TDY, TDZ.

Prx, Pry -

Cba, Cbb, Cbc -

Lcb, Lcb2, Lcb3 -

Stp - Data collect stop flag.

R(*) - Regression analysis summary array.

XY Plot

Sample - Sample number.

Wp_x, Wp_y - Plot origin.

Ap(*) - Current data sample.

R - Operating range about origin.

Cross/Along Track

Ct - Cross track distance.

At - Along track distance.

Rdist - Distance between START and STOP points.

Sample - Sample number.

General

PT$ - Plot data? "Y" = yes; "N" = No.

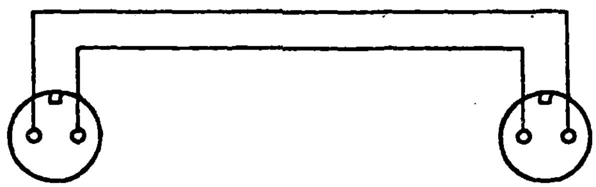
Plott - Type of plot desired.

CT$ - Cross track plot.

APPENDIX K

TWINAX CABLE PHASING

The proper phasing used in constructing Monitor System Twinax cables is shown below. Note that the left hand pin of the first connector goes to the right hand pin of the second connector.



ELECTRONICS ENGINEERING CENTER	
FIGURE 2-1 TWINAX CABLE PHASING	
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